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Two Essays on Government Behavior

Li Zhang

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TWO ESSAYS ON GOVERNMENT BEHAVIOR

BY

LI ZHANG

A Dissertation Submitted in Partial Fulfillment
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ACCEPTANCE

This dissertation was prepared under the direction of the candidate's Dissertation Committee. It has been approved and accepted by all members of that committee, and it has been accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics in the Andrew Young School of Policy Studies of Georgia State University.

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ABSTRACT

TWO ESSAYS ON GOVERNMENT BEHAVIOR

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NOVEMBER 15, 2005

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The main theme of this dissertation is government's strategic behaviors. We show that different budget structures give governments incentives to behave differently, and that the Leviathan model and the Bureaucratic model are better in modeling government behaviors than the median voter model. We first discuss theoretically the design of an optimal tax system, promoting the Leviathan government to maximize social welfare in order to maximize its own revenue. Then we examine empirically how government behaviors vary with different budget structures.

In essay I, we apply the Buchanan-Brennan (B-B) rule to examine the effects of a tax system on the efficiency of agricultural production in the context of Chinese local governments, which receive insufficient control from the central and are free from the pressure from local residents due to asymmetric information and lack of horizontal accountability. We extend the B-B rule to include the incentive issues and the risk sharing, and also their trade-off. Farmers and the agricultural sector assume significant roles in the national economy of China, while the under-provision of public infrastructures and the

risks involved negatively affect agricultural production and therefore impede economic growth. Within the principal-agent framework, we illustrate how the problem is inherent in the agriculture tax system in China and propose our solution of special earmarking.

In essay II, we test empirically for the government's strategic behaviors. We argue that the environmental performance is affected by government policy. Therefore it relates inherently to the budget structure and government incentives. With an illustrating model between structure of revenue and expenditure and pollution level, we propose three hypotheses, which state that the lower the ratio of business related tax in total revenue, the higher the ratio of property tax in total revenue, the higher the share of health expenditure in total expenditure, the government will have higher incentive to control pollution and thus the pollution level is lower. Our empirical evidence provides support to our hypotheses, which show that structures of revenue and expenditure do affect the government's incentives to control pollution. Therefore, changes in the budget structure might be helpful to achieve better environmental performance.

CHAPTER 1 INTRODUCTION

DOES GOVERNMENT BEHAVE STRATEGICALLY?

It is well known that taxes can distort the decision makers' incentive structures in an economy. Examining the impact of taxes on the behavior of economic agents is one of the most important issues in public finance theory. For example, in most of the public finance textbooks, the core consists of the impacts of tax on people's labor supply, saving, investment decisions, and the way people deal with risks. However, the government itself is assumed not to be affected by taxes in the traditional standard analysis framework. One of the justifications may be that economists believe in the median voter model. According to this model, the interests of citizens eventually govern government behavior (Rosen 1999).

Generally speaking, there have been three approaches to model government behaviors in the public finance literature: the median voter model, the Leviathan model and the Bureaucratic model.[1]

The median voter model is the most popular theoretical framework in the literature that deals with government behavior. Since government officials are elected by the general public, they can only stay in power if they satisfy the preference of the public. Due to the diversity of the preferences of different individuals, government officials can

[1] The ideal case of a benevolent social planner, who maximizes social welfare, even though socially as well as economically optimal, does not exist in the real world, therefore is not considered here.

only be elected or re-elected if they accommodate the majority residents' preference. Under certain conditions, the median voter's preference will win over in majority voting. Therefore government officials need to satisfy median voter's preference in order to stay in power or get elected. There is a vast literature that has tested the median voter model. To name a few, there is the pioneer work of Borcherding and Deacon (1972), and Bergstrom and Goodman (1975), Holcombe (1980), Gramlich and Rubinfeld (1982), and more recently, Turnbull and Djoundourian (1994).

Some observed facts make the median voter model flawed, however. For example, there exists an asymmetric information problem. The effectiveness of election depends crucially on the information on the candidates, while it is expensive for voters to collect this kind of information.

Alternatively, the government can be modeled as an organization with its own interests. In other words, the government is assumed to behave like an individual decision-maker, like a consumer or a firm. Since the citizens may not be able to control the government very effectively, the government may be trying to maximize its potential revenue sources, or using minimum resources to meet some requirements. This is the so-called Leviathan model, originated from Brennan and Buchanan, who describe government as a revenue-maximizing Leviathan (Brennan and Buchanan 1977, 1978, 1980). This Leviathan has an inherent tendency to maximize budgetary revenue; therefore the size of the government tends to be bigger than optimal. In the literature, the Leviathan model states that the more decentralized the government structure, the more

tax competition among decentralized governments will put restrictions on the government's intrusion into the economy, therefore, the smaller the size of the government. There is also a literature that elaborated on the validity of this model, and many studies arrived at different results. For example, Oates (1985) found no relationship between decentralization and government size, while Stein (1999) found that fiscal decentralization led to larger governments in Latin America; and some case studies found a negative relationship between decentralization and government spending, such as Marlow (1988) and Grossman (1989). Rodden (2002) differentiated between decentralization funded by intergovernmental transfer and local taxation, and demonstrated that in the former case, governments grow faster, while in the latter decentralization limits the growth of governments.

Also, even if the governments care about the interests of the residents, it may be difficult for the elected officials to control the behaviors of employees, or the bureaucrats in the government.[2] According to the so-called Bureaucratic model developed mainly by Niskanen (1968; 1971), bureaus are monopoly suppliers of the services they provide, with political sponsors as their monopoly buyers. And bureaus exchange a specific output with the political sponsors for a specific budget, unlike producers who trade other merchandises (Niskanen 1968). As he realized later, during the process of exchange, there exists bargaining between these two parties. Also the bureaus have information advantages on the production costs, while the sponsors do not have incentives to monitor

[2] Or even worse, the elected officials are bureaucrats themselves.

the behaviors of the bureaus. In addition, Bureaucrats have their own utility functions, including “salary, perquisites of the office, public reputation, power, patronage, ease of managing the bureau, and ease of making changes” (Niskanen 1975). Therefore bureaucrats will try to maximize their own interests, instead of maximizing the public interests. In term of budgetary behavior, bureaucrats will try to maximize the size of the their budget, in order to get more out of it, of course subject to the cost constraint of producing certain output. Later on, Niskanen modified his previous argument and pointed out that the bureaucrats maximize their discretionary budgets, or “the difference between his total budget and the minimum cost of producing the expected output” (Niskanen 1975, 1994). Niskanen also provided some empirical evidence on the overspending behaviors of the bureaus (Niskanen 1975).

Actually, Niskanen believed the reason that the governments choose bureaus as inefficient providers of government services instead of choosing more efficient private provision is that by so doing a net surplus is generated that can be shared with the members of the governments. Therefore, “most of the problems often attributed to bureaus are more fundamentally caused by the structure and decision rules of the legislature, for which bureaus are merely their preferred agents.” (Niskanen 1994)

Both of these last two theories posit that governments are similar to individuals, behaving in their own interests, reacting to different incentives, even though from different angles.

The Government Does Behave Strategically

In these three different models above, the latter two take into account the governments' or government officials' strategic behaviors, which we may apply to explain some phenomena that cannot be explained by the median voter model. A lot of studies that we are going to talk about in the following have been attempting to explain the real world experience by relating to governments' strategic behaviors, both theoretically and empirically.

McGuire (1999) reassessed the empirical outcomes on state-imposed limits on local property taxes. She found evidences that support the Leviathan hypothesis, rather than the median voter model.

Following Brennan and Buchanan, Glaeser (1995) examines the incentive issues behind the expenditure behavior of local governments. For a revenue-maximizing Leviathan, it is always in its interests to expand its tax base. In the context of property taxes, what the local government needs to do is to provide amenities. The quantities and qualities of amenities determine property values, based on which the local government collects its revenues. That explains why government has incentives to spend on amenities.

Observing that during the process of transition from planned economy to market economy, Eastern European countries and China have taken completely different paths in treating the new non-state-owned or private firms, Gordon and Li (1997) brought up their explanation. Local governments in China often support the new firms in order to gain the

related taxes and maybe part of the profits (Wong 1991). However, local governments in Eastern Europe economies often took a negative attitude toward the new firms (Blanchard and Shleifer 2000; Shleifer et al. 1996). To explain this, Gordon and Li link the difference of attitude toward new firms to the incentives faced by the two kinds of governments. They argue that the revenues of local governments in China highly depend on the new firms, while in other transition countries taxes mainly come from the existing state-owned firms. Therefore, different tax structures give governments different incentives to treat new firms. This shows that governments respond strategically to the different incentives provided by the tax systems.

Gordon and Wilson (1999; 2003) explore how the relationship "between tax structure and each bureau's budget can affect the policy choices made by these officials" (Wilson and Gordon 2003). They observe the absence of government in the discussion of optimal taxation, arguing that the taxation system cannot be optimized unless we take into account the response of government officials to the tax structure. Their conclusion is that government officials always prefer the policies that can expand tax bases. For example, in terms of environmental policy, governments are most likely to choose Pigovian tax over allocating free permits to the current firms. The reason is that the Pigovian tax can contribute the revenue increase to governments, while the latter cannot.

Local government in China provides another good example to analyze the incentives behind government behavior. Due to the characteristics and special roles of

Chinese local governments in illustrating the governments' strategic behaviors, some empirical studies examining Chinese local government behaviors are worth noticing.

As we will discuss in detail later, there is no horizontal accountability in the political system in China, because local officials are not subject to the re-election pressure, and most of them are appointed by the higher-level government. In determining the appointment and promotion of local government officials, revenue that they collect is usually one of the most important criteria. Under this context, local government has very strong incentive to maximize the revenue that can be collected. It is interesting to note that before the 1994 tax reform, local governments were able to manipulate the tax rate and the tax base to maximize the revenue they could collect in their jurisdictions. The 1994 tax reform assigned the power to change the tax rates only to the central government. This restriction itself is a response by the central government to the previous strategic behavior of Chinese local governments under incompatible incentives. Local governments try to increase their own revenues at the cost of reducing central government revenues. Wong (1991; 1992) documented some serious problems of Chinese local governments. For example, Wong wrote, "they [the three features of the tax system] have created problems of persistent overinvestment, duplication, regional blockades, and continuing bureaucratic management of industry" (Wong 1992). There even existed some regional barriers to resources flows, such as in the case of the "wool

war" and the "silk cocoon wars" (Wong 1991).[3] These kinds of behaviors surely were rational responses of local government to the tax system, because in those days the most important tax was from the manufacturing activities. The central government issued a lot of regulations, trying to put an end to these behaviors, but the regulations hardly ever worked since the inherent incentives encouraged the local governments to circumvent and not comply with them.

Huang (1995) shows how the local governments' investment behaviors respond strategically to the monitor of the central government. In the 1980s the Chinese economy was still controlled by the central plan. But the central plan suffered from high monitoring cost. For some investments, it was easier to monitor and control; for some others, however, the monitoring cost was pretty high. With renovation investment and construction investment as examples, Huang shows that in the 1980s the Chinese local governments always chose to invest more on renovation, on which the monitoring costs by the central government were higher, so they can take advantage of the central government's inability to effectively monitor and therefore harvest the benefits of noncompliance.

For a Leviathan-like government, as in the case of China, if it lasts more than one period, it will try to allocate the current resources to maximize the expected future

[3] As Wong (1991) put it, in response to the decline of resources allocated by the central government to the local governments, they try to protect local tax bases, and one of the consequences is the regional protectionism. Due to the dependence of local revenue on the development of local enterprises, local governments promote local tax bases by supporting local economic growth, or "intervene whenever possible to protect their resources and markets". They ban the free flow of wool and silk cocoon prompted by market mechanism between localities, in so doing bringing about the outbreaks of "wool wars" and "silk cocoon wars".

revenue. The local government may behave exactly like an investor in that where to spend the current resources will depend crucially on the expected payoffs from the "projects" in the present period. If some public sector projects cannot bring back tax revenue, the local government will not spend much on them, unless it is required to do so by the central government. In their article, Zhou and Zhao (2002) show that in the two Chinese townships, the government expenditures on the agricultural sector are only 3.39% and 1.37% respectively. This is partly due to the fact that the Chinese current agriculture tax is fixed and not related to agriculture production, and spending on agriculture and increase production will not bring more revenue. As a consequence, governments have no incentive to invest in the agricultural sector. This will be the object of our analysis later. On the other hand, the expenditures on education are 48.33% and 22.85% respectively. Such a high share of resources were allocated to education, even though it can not bring about revenue in the short run, because the central government mandates that the local governments give priority to education in their budgets. In addition, the two township governments paid 5.49% and 2.91% of their revenues to their tax administrations. Compared with the tax administration in the United States, which costs only around $10 for $1000 revenue collected, or 1% of the revenue, the situation in China clearly shows a substantial X-efficiency in the local public sectors.[4]

In addition, differences in tax base give local governments different incentives, which in turn lead to different expenditure behaviors. Han (2002) and Zhao (2002)

[4] For further information, please refer to the following website: http://www.co.fairfax.va.us/gov/omb/pdf/Volume1/00157.pdf, last retrieved Nov. 08, 2005.

investigate the expenditure behaviors of three less developed county governments in China. Zhou and Zhao (2002) provide a picture of how a local government in a rich prefecture allocates its fiscal resources. From their studies we can see that there obviously exists some difference between the behavioral patterns of rich local governments and poor local governments. The difference is exactly the consequences of different governments' revenue maximization behaviors. The tax bases for governments in rich and poor area are different, since the government in the rich area collects its revenues mainly from industrial activities, while the government in the poor area may rely heavily on agriculture sector for its revenue. For the former, the tax bases are related to the industry production, so the local government spends a lot in outlets that are conducive to production expansion in order to collect more revenue. For the latter, the local government fulfills its revenue objective by imposing heavy levies over and above the fixed agriculture tax and exploiting the farmers. While the agriculture tax is not related to the agriculture production, the public goods provision in agriculture sector is not conducive to the revenue increase, which gives local governments little incentive to expend on agriculture sector.

The above review tells us that governments do take on strategic behaviors. More fundamentally, evidences show that the governments behave differently under different tax structures. It is safe to draw a conclusion that even though in countries where government officials are elected by the voters, election by itself may impose restrictions on the behaviors of government officials and thus affect government behavior, it is not

guaranteed that government will behave completely in the voters' interests. More importantly, modeling government as a revenue-maximizing Leviathan might be a better choice in an economy where election does not exist. This demonstrates that the assumption in traditional public finance literature that governments are free of the impact from taxes is unrealistic, and therefore it needs to be reconsidered.

In addition, the strategic behaviors by the governments take many forms and have significant welfare effects, as exhibited by the strategic behaviors of some local county governments in China. In Tuanfeng County, Hubei Province, for instance, the county governor dismissed the County Office of Environmental Protection in 2003. The governor made this decision because the environmental protection office "disturbed" the local firms' production activities, making products manufactured by the industries within the county more expensive and thus less competitive. Thus the environmental office was dismissed because its behaviors threatened the county's tax base. Another example is also from Hubei Province, China. The governor of Jianli County took a big step on reforming education system, selling all profitable elementary and middle schools to private investors and meanwhile shutting down those non-profitable schools (Liu 2003). By doing so, the county government no longer had to allocate budgetary expenditure on education, which could not bring about any immediate tax revenue.

These examples show how a "bad" constitution can have seriously negative welfare effects. In the first case, local government collects revenue from industries, rather than from property. If there is a conflict between environmental protection and the

expansion of the tax base, letting the firms continue their production and therefore continue to pollute would be optimal for the sake of protecting local government's tax base. Therefore a rational choice is to "dismiss" the environment office. In this process the interests of the local residents are being sacrificed, however. In the second case, it may be irrational for local officials to allocate a big share of budget to education because, from the perspective of the local government, education is thought to be a pure expense without any immediate return. After the reform, education becomes an industry from which private investors can charge high tuitions and make profits. Children in that county can no longer enjoy free compulsory education and it will become difficult for children from poor families to afford education. These kinds of government behavior demonstrate that it is really important to take into account the incentive issues in the design of tax structure.

As discussed above, the governments do behave differently under different tax structures. Therefore, in term of efficiency, optimal tax design is of great importance. This issue is more important for economies in which voting system does not work very well. An observed fact is that the government in advanced economies is subject to horizontal accountability, since in these economies, the re-election is a pressure for the government officials. Therefore the officials should take into full account the interests of the general public and are accountable horizontally to them, in order to gain their votes. In some countries like China, however, the local government officials are appointed by the higher-level government therefore there is only vertical accountability in that the

officials are accountable vertically to their superiors and care about the preferences of the higher-level government. In this context, local officials would not respect the interests of residents in their justifications and this horizontal accountability does not exist, unless the residents' interests are related to those of the higher-level government.

Combating the Revenue Maximization of a Leviathan-like Government

Various examples exhibit that the governments do take on strategic behaviors, then the problem now is how to combat their strategic behaviors. For a Leviathan-like government, seeking for ways of dealing with their revenue maximization should be in place.

What is an optimal constitution, or optimal tax structure in general?[5] From the perspective of the traditional framework, the answer lies in minimizing the excess burden associated with some given revenues. Ramsey rule gives a good solution, but it considers efficiency only (Ramsey 1927). Also, the Diamond Rule is another choice if we take into account horizontal equity (Diamond 1975).

For a Leviathan-like government, the social planner's problem is not only to minimize the excess burden for given government revenue, but also to deal with government's strategic behaviors. The government has both incentives and discrete power to manipulate the "investment" of the current resources in order to harvest future returns. In other words, all the current resources will be optimally, in term of revenues

[5] We think it would be interesting to expand the analysis to include expenditure so we can discuss budget structure in a more comprehensive way, like we will do in the second essay.

will be collected in the future, allocated to the sectors that can yield highest returns. In this sense, the local government behaves likes a corporation (Oi 1996). The Leviathan government may spend nothing on some public sectors if they cannot "harvest" tax revenues from them according to the constitution (tax structure), while allocating subsidies to the sectors contributing to revenue growth.[6] In this sense, the optimal choice surely should include the efficiency issue.

When it comes to efficiency, there is an important issue that needs to be stressed. In order to collect more revenue, improving on the efficiency of tax administration, taking into consideration both the tax capacity on one hand and the tax collection efforts on the other, is assuming a significant role. However, with the objective of dealing with the strategic behaviors of local governments in this volume, we pretty much leave this issue out. Nevertheless, it should be noted that it plays a very important role in enlarging tax revenue collection in the context of the tax system in China.

Among the models examined above, the median voter model has a built-in mechanism to limit government behavior: voting. If the government official does not satisfy the preference of the median voter, which stands for the majority election's preference, he will be voted out of the office. Therefore, being accountable horizontally to the public is a must for government officials behaving purely in the voters' interests.

If the governments are not constrained by the election pressure as in a democratic system, neither are the governments like the market-preserving federalism type that

[6] In this paper, sometimes "constitution" and "tax structure" are used interchangeably.

Weingast et. al. present, what constraint can we construct to put a limit on the behaviors of governments (Qian and Weingast 1996, 1997)?[7]

Basically, two approaches can be followed for dealing with the Leviathan-like governments. The first one is to let the governments compete with each other. The competition can be realized in two ways. One is to decentralize powers in the hands of central governments to local governments. Not only can lower level of governments better accommodate the preferences of local residents, but also voters at the local level are in a better position than central government to monitor local government behaviors, thus decentralization can solve at least part of the asymmetric information problem. In this respect, there is going to be efficiency gain by inducing competition among local governments. There are also costs involved in term of the loss in efficiency in the economies of scale and scope. The other is fragmentation. For powers already in the hands of the local governments, we can artificially build more governments at the same level, and then let the constructed market work as an intermediate mechanism to reshape government behaviors. There is a huge literature on the effects of decentralization and fragmentation on government behaviors (Nelson 1986; Oates 1985; Zax 1989). However, the induced competition may not work effectively when governments behave strategically.

[7] The theory of market preserving federalism advocated by Weingast, Qian et al. states that, under the conditions of hierarchy shaped and institutionalized clearly divided assignment of government responsibilities with the authority of the local governments over the local economy, hard budget constraint for all level of governments, formation of common market to ensure the mobility of factors across localities, the vertically separated and decentralized federalism is actually a effective mechanism to preserve market incentives. For details, see Qian and Weingast (1996; 1997) and others.

Alternatively, we can use direct measures to make governments behave desirably. In terms of constitutional economics (McKenzie 1984), in order to limit Leviathan's taxing power, the only way is to lay some rules at the constitutional stage, which means to erect legal restrictions, stipulating what can be done and what cannot be done before constitution is established. Proposition 13 in California is one of the most famous cases.

At the after-constitutional stage, however, voters may not have effective measures to make government behave desirably, even when the government is under the pressure of pursuing re-election (Brennan and Buchanan 1980).

What we should be concerned with here is to make the tax structure compatible with the incentives of government. Public goods provision is important to both the consumption and production activities. If voters could not control government tax collection behaviors, they would not be able to control the government expenditure behaviors. One view, as proposed by Brennan and Buchanan (1978), can be used to solve this problem. In their path-breaking research, Brennan and Buchanan (1977; 1978; 1980) "drop the central assumption that budgetary spending and taxes are determined through an effectively democratic voting process in the postconstitutional period" (Brennan and Buchanan 1978). Instead, they assume that voters can set up rules to constrain government, which is assumed to be a selfish organization trying to maximize its own interests. For different rules placed by the voters, the government may respond very differently. If voters cannot effectively monitor government behaviors, the government does not have incentives to satisfy voters' preferences. Therefore, it is optimal for

government, in some circumstances, not to spend on those outlets that are important to voters but are not conducive to the growth of government revenues. Under this circumstance, the optimal choice for voters is to induce "a Leviathan-like government to provide the public goods and services that taxpayer-beneficiaries desire" (Brennan and Buchanan 1978). From Brennan and Buchanan's perspective, the basic rule is to relate tax base complementarily to the provision of public goods at the before constitution stage. To put it another way, they advocate some special form of earmarking. They believe that "effectively designed earmarking may limit the extent to which government, any government, can exploit the taxpaying public," and "government may be given a positive incentive to provide the goods and services that taxpayers want" (Brennan and Buchanan 1978). In so doing, the increase in the public goods provision will lead to the expansion of tax base. They also believe that this rule is consistent with a Leviathan's incentives and, therefore, will be self-enforcing. The maximization of revenue could be realized either by expanding tax revenue, or, when there is no room to expand tax revenue, simply by keeping the expenditure as low as possible.

This rule (thereafter we call it "B-B rule") points out the key problem in the theory of mechanism design. For a tax structure to be "good," it must solve government's incentive problems.[8] In other words, it must combine the voters' interests together with that of the government's.

[8] Where "good" means efficiency supporting.

However, rule setting needs to be contingent; therefore there always exist loopholes. Taken as a contract, a constitution by nature is incomplete and cannot exhaust all possibilities. It would be very difficult to construct a good constitution. Meanwhile, B-B rule suggests directly taxing public sectors, which seems a little bit implausible in reality.

CHAPTER II

ESSAY I TAX STRUCTURE, MORAL HAZARD AND CHINESE LOCAL GOVERNMENT BEHAVIORS

The current budget system in China provides a natural experiment to examine the Leviathan model. In this system, essentially the local government receives no pressures from the local residents. In other words, there is no horizontal accountability for the local officials. The local governments are at least free from the pressure of re-election, even if it is unrealistic to say that they do not need to serve the interests of local residents. From this perspective, we take the Chinese public finance system as a good example to study the behaviors of Leviathan-like governments. Therefore, in order to have a better idea of how incentives can influence government behaviors, here we will focus on the behaviors of local governments in China. There are 5 levels of governments in China: the center, provinces, cities or prefectures, counties and townships. Each level of government plays different roles, takes on different risks, has different degrees of fiscal discretion, and is affected very differently by the "constitutions." Generally speaking, each government is responsible more directly to the next higher level of government. However, even though the provincial government is the one that is directly accountable to the central government, the central can intervene in local issues in county and even township level governments. There is usually no delineated expenditure responsibilities assignment

among levels of governments, which makes it difficult sometimes to differentiate which level of government is responsible for what. In our notation of the general introduction to the system in China in the following part, unless explicitly specified, when we use local governments, we usually mean it in a general sense, which includes all sub national levels of governments.

Tax System and Local Governments in China

It is observed that there exist some paradoxes in the behaviors of local governments in China. Across the whole country, local governments are trying their best to attract investors into their localities, including investing a lot on infrastructures, granting preferential tax policies, and so on. Sometimes local governments' efforts to recruit enterprises are even being carried out at the costs of huge side effects, such as serious pollutions or spreading of environmental related diseases. In rural China, however, local governments have been investing very little on such infrastructures as roads, wells, dams, and so on. In cities, the local governments refuse to give nonresidents rights that are equivalent to what city dwellers are enjoying, to use public schools, hospitals and so on, or alternatively charge them higher fees.[9] Also, in order to reduce the public expenditures on education, local governments deregulate the operations of the school system, allowing schools, especially top schools, to charge students elevated

[9] In China, the household registration system, "*hukuo*," that shows where you have legal residency and put restrictions on cross region labor migration, is still quite strictly enforced. It came into effect in 1948, and dividing households into rural or urban residents, with urban residents having access to foods and other facilities subsidized by the government, also being employed by state-owned enterprises. See Roy Bahl and Jorge Martinez (2003). The local residency cannot be changed simply by renting or even owning a place to live in a particular locality, different from what is in the United States. It has to satisfy certain requirements, going through certain complicated official procedures and generally are very difficult. The households are asked to prove their local urban residency before entering schools in cities and towns, otherwise they will have to pay much higher fees than normal tuition.

tuitions. As a consequence, schools become monopolies, with higher prices and lower enrollments for education than before. These seemingly unrelated phenomena are, according to our point of view, in fact implicitly connected with each other through the local governments' incentives of pursuing revenue. Local governments are encouraging or making efforts in activities that will bring about more revenue, while discouraging or compressing activities that are not contributing to revenue increase.

Some background about the Chinese budget system

Before carrying out more detailed analysis of local government behavior in China, some background information is in order. The Communist Party of China, the ruling party, has a strictly hierarchical structure, and generally higher-level government determines the appointment, promotion and dismissal of lower level government officials. Since there are no elections, there are no correlations between the stay-in-power or promotions or dismissal of local government officials and satisfying the preference of local residents; therefore local government officials are not accountable horizontally to the public. Instead, local government officials are generally accountable vertically to higher-level government, who determines their appointment and promotion. Local government officials do not have to care about satisfying local residents' preferences unless upper-level government officials do. Sometimes in order to achieve their goals they may even sacrifice local residents' interests. As we mentioned above, they might try to take in investors who can bring about huge environmental problems to the locality.

It is observed that, since higher-level government plays a vital role in local government officials' political career, the latter will try all means to please the former. According to Edin (2003), the principal criteria of evaluating public officials include political integrity (*de*), competence (*neng*), diligence (*qin*) and achievements (*ji*). Among them, achievement is the most important criterion, account for 60 to 70 percent of evaluation of the performance. The reason is that the other three criteria are often based on the subjective assessment of higher-level government, unlike the achievement criterion, which is more objective and verifiable, and therefore more comparable and more incontrovertible. This gives higher-level government greater information advantage in evaluating officials. Under the strategy of "*fa zhan shi ying dao li*" (means development is what really counts) that the communist party of China has been advocating for the objective of catching up with developed countries, GDP maximization has been included in the central government's policy agenda for years. In order to guarantee that central government has enough resource in fulfilling objectives of macroeconomic control and economic development, revenue collected by local governments and remitted to the central government is of vital role. That is why revenue collected by local government is one of the most important criteria that higher-level government uses in assessing local officials' achievements.[10] Under this context, local government officials' strategy of pleasing higher-level government can be safely

[10] Or, alternatively, with more revenue collection, it's easier for local government officials to achieve objectives central government uses to assess their performance.

summarized in the objective of maximizing local revenue. Local government officials would try their best to mobilize revenue from all sources, in addition to taxes, in order to remit more tax revenue to the center on one hand, and keep more revenue in their own discretion on the other. The retained revenue is indispensable in fulfilling their expenditure responsibilities, which are usually the mandates of the central government. Another part of it, maybe more important, is used to invest on items that are conducive to tax revenue further increase so they can access more revenue in the future. From this perspective, local officials' revenue maximizing behavior itself is aimed at maximizing their own personal benefits, either political benefit as stated above or monetary benefits, since more funds at hands enable local officials to pursue "perks" more easily or simply can bring about more cash bonus. Therefore, besides the Leviathan model, the bureaucratic model is also likely to have some explanatory power in modeling local government behaviors in China. That is why we are trying to construct a model, combining the essence of Leviathan model and Bureaucratic model in the following section.

The fiscal system in China has experienced a series of changes and reforms. Revenue maximization has entered local government officials' objective function ever since the tax contracting system was founded in 1984.

Before the tax reform in 1980s, local governments at best acted as agents of the central government, who collected revenue on behalf of the latter and handed it over to the center. Then central government allocated the revenue according to different factors

back to the provinces. Local governments would bargain with the center in order to get more revenue allocated. Back then the government revenue mainly consisted of profits from state-owned enterprises. Local governments did not have an incentive to mobilize more revenue since all of their expenditure came from the allocation of the central government. Greater bargaining power was more important than capability of collecting more revenue.

The revenue contracting system, started in 1984, put an end to this situation. Under the contracting system, based on different fiscal conditions of individual localities, provinces were grouped into 6 types of different revenue-sharing contracts they had with the central government, either remitting certain amount or some proportion of collected revenue to the center and retaining the rest, taking the forms of “basic sharing,” “basic sharing with growth,” “incremental sharing,” or “fixed quota” or “fixed quota with growth” (Bahl 1999); or receiving certain amount of subsidies from the center (Knight and Li 1999). For example, “basic sharing with growth” means that “revenue growth up to a defined limit was divided between center and province according to a formula;” and “both the limit and the sharing ratio were negotiated. The province could retain all collections above the limit” (Bahl 1999). Since the contracts were fixed before the revenue was collected by the local governments, local governments always tried to find ways to keep more tax revenue collected away from the remittance to the center so as to keep more as their retained revenue. One important choice was to channel revenue into extra-budgetary revenue or even off-budgetary revenue, a subject to which we will return

later. Another choice was to grant preferable tax rates or tax breaks to local enterprises, in exchange for more non-tax revenue, which were in the local governments' interests but impairing the central government's interests. Meanwhile, the central government, after the provinces had collected the revenue, often reneged on its promise and asked for more than what stated in the contracts from the provinces (Ma 1995; Ma and Norregaard 1998). Therefore the relation between the center and the local governments was pretty much *ad hoc* and adversarial instead of following certain rules and being cooperative. The lack of constraints to both the central and the local governments made it difficult to quantify intergovernmental fiscal relations in China. Since the profits from state-owned enterprises had been gradually changed into taxes, tax revenues became the major source of government revenue. By that time local governments already started their revenue mobilization. But since the fiscal relations between the local and the center were according to certain predetermined contracts, even though the contracts were not implemented strictly, revenue collection was not so important in evaluating the performance of local government officials. Local government officials cared more about the retained revenue after remitting to the center, as well as extra-budgetary revenue and off-budgetary revenue over which local governments had full discretion. This is one of the reasons why the ratio of central government's revenue to total revenue kept falling in the 1980s and early 1990s. In addition, the ratio of government revenue over GDP kept diminishing, too, contrary to what "Wagner's law" predicts. Mainly owing to the falls of

these two ratios, new tax reform was undertaken at the end of 1993 and was implemented beginning in 1994.

The 1994 tax reform claimed to make a fundamental departure from the old system.[11] In 1994, taxes were divided distinctively into central taxes, local taxes and shared taxes. There was also a significant change in tax administration: the newly founded national tax bureau, separated from the local tax bureau. Each of these two tax administrations is responsible for the collection of central taxes and local taxes, respectively, with the shared taxes falling into the territory of the central tax bureau and then shared between the central and the local governments. Simply put, one of the major parts in shared tax is value added tax, with 75% of the tax revenue kept by the central government and 25% allocated to the local.[12] It also includes the corporate income tax, personal income tax and security transaction tax, and etc. VAT has been assuming more and more a more important role in total tax revenue. In 2000, VAT, together with other business-related taxes such as sales tax and consumption tax, took almost 80% in total tax revenue. In 2003, the VAT alone still comprised almost 50% of the central tax revenue and 20% of the local tax revenue with a average of 36% in total tax revenue (China statistical yearbook 2004). Now local governments' enthusiasm of mobilizing revenue is more than ever before. Since economic development becomes the priority of the central government, more local revenue means more resource in fulfilling local

[11] As it turned out later, this claim hasn't been fully justified.
[12] The corporate income tax is shared based on the property rights of the enterprises in question, the personal income tax is shared with 60% goes to the center and 40% goes to the local, and the security transaction tax is shared equally between the center and the local (Liu 2004).

governments' development targets and therefore becomes very important in evaluating local government officials' performance. For the shared taxes, even though the share to local governments are fixed, local governments can always get more if the total amount of the shared revenue is higher. Besides, as we mentioned above, the VAT revenue takes a very big share in total tax revenue. Therefore, local governments usually take great efforts to mobilize shared revenue. Local taxes, which are completely within local governments' domain, apparently are also their revenue maximizing targets. With revenue maximization as their objective, local governments' behavior is centered on how to mobilize more revenue, in addition to tax revenue. They will engage in activities that are conducive to further increase revenue and discourage or even try to compress activities that cannot bring about more revenue.

Though there have been some big changes in the Chinese tax system, the basic incentives behind the local governments stay almost the same. The voting system still has no role to play at all. All levels of local government officials are still appointed by their superiors. The local officials have no incentives to satisfy the local residents, as predicted by the median voter model. Also, as mentioned above, collecting more revenues or constructing more factories are still important and necessary (though not sufficient) conditions for the local officials to get promoted. In short, in the new context the local governments are still Leviathan-like, and, for the reasons stated below, their revenues depend on the taxes to an even greater extent.

Local governments' revenue maximizing behavior is not without any constraints. Some arrangements made in 1993 by the central government, along with other institutions that have long been effective, serve in effect as constitutional constraints that Brennan and Buchanan proposed to local governments. Central government knows well that, given that local residents cannot migrate freely across regions, neither can they choose government officials through voting, local governments have a tendency to extract too much fiscal resources from local residents.[13] Therefore the central government imposes some constraints on local governments' revenue mobilizing behaviors. First, central government determines the type of taxes, and local governments cannot levy new taxes. Second, the tax rates for all taxes are predetermined by the central government, and local governments generally have no discretion.[14] These two constraints applied to central taxes, shared taxes, as well as local taxes. Tax revenue is determined by tax rate and tax base. Now that the tax base is the only variable local governments can actually adjust, local governments can only achieve tax revenue maximization by enlarging the base of the taxes to which they are entitled. They cannot obtain higher tax revenue by marking up tax rate. Additionally, capital in China is relatively mobile compared with labor, especially FDI, partly owing to the still effective Household Registration System, the so-called "*hukou.*" For local governments, more capital investment means larger tax base. Local governments were able to grant preferential tax

[13] To put this in the traditional term of public finance, this is to say that local residents can neither "vote with the foot", nor "vote with the hand."
[14] There are some exceptions, even though quite minor, such as the urban construction and maintenance tax and property tax, somehow gives a signal that the central government is now taking more liberal route.

rates and other tax breaks to attract foreign investors before 1994 tax reform. After 1994, these tax concessions are not permissible any more. Local governments could also reduce the enterprises' financing costs by making state-owned banks loan out funds at lower than market interest rates, the so called "policy lending." After the financial reform in the 1990s, this kind of policy lending is no longer a policy instrument for local governments. These changes in concert impose further constraints to local governments' revenue maximizing behavior. They have to find alternative ways to attract investors. Of course, as we noted above, improving on the efficiency of tax administration, or improving on the rate of tax collection is always a strong economic instrument that local governments can employ. But in this paper, for the incentive problem that we are dealing with specifically, we do not give it as much attention as it deserves.

Therefore, on the one hand, local governments encounter more contingent constraints in raising tax revenue than before; on the other, they are taking on more expenditure responsibilities, partly owing to the fact that there is no delineate expenditure assignment between level of governments, which enable higher level government to shift expenditure responsibilities down to lower level governments. Local governments are now more attempted to engage in revenue maximizing activities. Here we should interpret the "revenue" in a more general sense: it includes not only tax revenue that we mainly dwelt with above, but also the revenue from other sources such as user fees and various surcharges.

It almost becomes a tradition in fiscal reforms in China that only the revenue side is tackled. The latest fiscal reform in 1994 is a case in point. It reassigns revenue between central and local governments, while no corresponding expenditure reassignments have been made. As a consequence, the center shifts some responsibilities to the provinces, and the provincial governments in turn shift their responsibilities down to the lower level governments. In China, unlike most of the developed countries, expenditures on items with huge externalities and basic human development such as education, health and even social security are responsibilities of local government. Due to the importance of these expenditure responsibilities, some of them are mandated by the central government, however without corresponding revenue assignments, therefore become **"**unfunded mandate.**"** The most important one is "the setting of wages for local civil servants by the central authorities" (Bahl and Martinez-Vazquez 2003). These mandates "provided organizational incentives for local agencies to maximize their quest for financial resources, as evaluation of performance of local officials created personal incentives to raise revenues" (Bernstein and Lu 2003). Budgetary revenue apparently is not enough for the increased expenditure responsibilities for lower level governments; therefore revenue sources outside of budget become indispensable to local governments. Extra-budgetary revenue and off-budgetary revenue have long been local governments' revenue sources in implementing their expenditure responsibilities. In some years the amount of extra-budgetary revenue sources was even comparable to budgetary revenue. It often happens that local government divert budgetary revenue to extra-budgetary revenue to

avoid remitting the latter to the center and so have more discretion over it, which contributes to the diminishing of the share of central government revenue in total revenue. "The practice [of tapping extra budgetary funds to finance government expenditures] is so pervasive that extra budgetary funds are commonly considered a 'second budget,' whose availability substantially alleviates the revenue squeeze at the local level" (Wong 1991). That made central government narrow the definition of the latter and try to include more revenue sources into budgetary management in late 1993. However, besides extra-budgetary revenue, off-budgetary revenue, which comes from "ad hoc charges, unauthorized fees, forced 'contributions,' and the like" (Wang 1997), is completely outside central government's budget control. Even before the 1994 tax reform, local governments had levied various fees and surcharges, part of which was used to make up their expenditure shortage. Some of the extra or off-budgetary revenue are employed to finance the local governments' expenditure responsibilities that can not be fulfilled with the budgetary expenditure. For example, some of the health fees were rolled out directly to health spending. But not all of the extra-budgetary funds are used in this legitimate way. For example, one story tells that the fees from the bureau of social planning were used to construct the office building for the local government.[15] There was certainly a considerable amount of this fund being used to satisfy the personal interests of local government officials, whether to pursue the "perks" or directly as their cash bonus. In rural areas of China, these fees and levies have long been a heavy burden for farmers and,

[15] This is from the author's own experience in Henan Province, China.

given its nature of coercive collection and improper usage, contribute to the social instabilities in rural China. That is why the central government has been trying to enforce the administration of extra-budgetary revenues and reduce or eliminate illegal fees and surcharges. However, it has not been very successful.

It should be noted that the behaviors of local governments are the responses to the arrangements of central government. These arrangements are similar to the case of Proposition 13 in California, in that they both put strict constraints on the revenue side at the local level. Our conjecture is that, under these constraints, in order to maximize tax revenue, local governments would try to enforce the tax collection as strictly as possible, reducing the expenditure to the minimum level, and rearrange their expenditure budgets and their compositions to attract the firms into or keep them from moving out of the locality, with the goal of enlarging their revenue base. They would expend more on expenditures that are conducive to more taxable activities, such as infrastructure, in order to obtain higher revenue in the future. They encourage investment because they can collect VAT and other business taxes from firms' production activities. They refuse to expend on education and health because, as they see it, they cannot derive much revenue and so cannot benefit much from these expenditures, unless the central government mandate otherwise. Therefore, expenditures on such basic human development as education and health services have become relatively less important. [16] Similarly, they

[16] The case for education is better since the central government mandate that local governments put priority to education.

refuse to treat nonresidents equally because they cannot collect income tax from them. However, in rural areas where they can only collect head tax, which is in fact a fixed amount for every farmer, unlike VAT and other business taxes, which are proportional to actual productions, they can not benefit from investing on rural infrastructures; therefore they would make as little efforts as possible in expending on local public goods in rural China in order to reduce expenditure.

Some Important Facts about the Tax System in China Need to Be Stressed

The current tax system in China has been examined intensively since it was established in 1994. For example, Bahl (1999) discussed the whole system and paid special attention to the effects of tax reform on the fiscal relationship between central government and local governments, the tax administration etc. A series of World Bank reports were also published, such as the one in 2002, which analyzes the current inter-governmental fiscal relations, pointing out the problems in revenue and expenditure assignments, and proposing ways to fix these problems. Bahl and Martinez (2003) examined the role that fiscal federalism plays in the context of economic growth, modernization and globalization and various aspects of economic reform in China. Xu (1995) summarized the backgrounds of tax reform, and introduced the process of fiscal reform in detail. Martinez-Vazquez and Zhang (2002) examined the evolution of the fiscal transfer system and pointed out the existing problems. Huang (1995) and Wong (1991) studied the relationship between the central and the local, with special attention to the strategic behaviors of local government.

Among various aspects of tax system in China, there are some important facts that need special attention.

First, even though widely considered to be a decentralized fiscal system (Qian and Weingast 1996; World Bank 2002), at least from the fact that the expenditures by subnational government make about 70 percent of government budgetary expenditures (Bahl and Martinez-Vazquez 2003), the tax system in China strikingly demonstrates that it is the central government itself that is in charge of the tax base and tax rates. This is totally different from a federal fiscal system.[17]

In China, the centrally determined tax structure and tax rates are applied to all local governments without considering the characteristics of individual localities. Uniform is by no means an efficient arrangement in China because China is such a big and diversified country; geographically, democratically and economically.

Second, the current tax system has been useful in dealing with the specific problems facing the central government at the time when it was designed and implemented. For example, in 1993 the Chinese economy was under heavy pressure from inflation. The consumption based VAT was designed to counteract the firms' investment enthusiasm because the inflation was believed to result from firms' over investment (Xu 1995).[18]

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[17] As an example of federal fiscal system, the states in the United States surely have the power to choose tax bases and rates in their jurisdictions.

[18] The VAT can be classified into consumption-type VAT and income-type (which further classified into gross income-type and net income-type) VAT according to the different treatment to investment assets. The consumption-type VAT excludes investment and therefore includes only consumption, in effect a kind of sales tax. See Rosen (Rosen 1999).

Meanwhile, the designers of the tax system believed in their capability of making the local officials do what the central government desired, and often ignored the significant role that incentives can play in shaping local government behaviors. As mentioned above, even under the pressure of re-election, the governments in western countries still adopt strategic behaviors. When there is no election pressure, the enthusiasms of taking on strategic behaviors would be even greater. The Chinese local governments not only lack horizontal accountability, but are also subject to little monitoring from the higher level government because of generally high monitoring costs. They would not follow what the higher level government expects them to do if the incentives from the tax structure are incompatible with their interests. For example, in September 1993, when the contracting system was still under way, in order to guarantee the launching of the new tax sharing reform and mitigate the resistance from provincial governments, the central government adopted a major concession towards provincial governments. That is, based on the hold-harmless principle, the center promised to give tax rebates back to the provinces, and "guarantee that the level of each province's revenue after 1993 would not be lower than that in 1993" (Wang 1997). In order to do that, the policy makers needed to determine the base year, based on the revenue in which the central government can determine the amount of tax rebate from central to each province according to some formula (Martinez-Vazquez and Zhang 2002; Wang 1997; Wong 2000). Since higher base year revenue will lead to a higher rebate in the future, the provincial governments would have incentives to manipulate the tax revenues in the base

year in order to get higher rebate in the future. The central government finally announced 1993 to be the base year in September, 1993. As a result, from September till the end of 1993, the tax revenues collected by all provinces increased dramatically. For example, compared with the year before, in September alone the revenue increased by 60%; in October and November, the increases were 80% and 90% respectively. In December, the figure was doubled and reached 120% (Zhao 2003). The strategic responses from provincial governments load heavy burden on the central government in the process of implementing tax rebate policy in 1994 tax reform.

Third, there exist risk issues in the current tax system. Because the local tax base is fluctuating, the local governments have incentives to stabilize their budget revenues. One way to stabilize the budget is to shift expenditure responsibilities to the residents and make the residents pay for the provision of public goods and services by themselves when a financial crisis occurs. Sometimes, the shift of expenditure responsibilities may not only result in the under-provision of public goods and services in the locality, but also put local residents into difficulties. The reduction in services obviously violates the regulations issued by the center, and the invasion into local residents' lives goes further against the central government's endeavor. If the bitterness from the suffering local residents can catch the center's attention, the center may take some economic or even political actions to discipline the misbehaving local government. Punishment in this form, however, rarely happens since voices from the grassroots can seldom reach the center. Consequently, local government's conduct of fulfilling the expenditure assignments by

invading local residents' lives happens quite often, not only in the educational sector, but also in other basic service sectors such as agriculture supporting funds.

Even in the case that the fluctuation is not a serious problem, the total revenues within local governments' discretion are limited. Regulations issued by the central might impose risks on local revenues in the sense that the constitutionally imposed expenditure responsibilities leaves local governments with less discretion over the remaining revenue, thus is equivalent to a reduction in local revenues. For instance, if the central issues an order to guarantee the teachers' salaries, expenditures on other public services have to be reduced or even revoked. For example, in Xiangfan, Hubei Province, the payment arrears are transferred from education sector to government departments. A lot of government employees, even those in the Revenue Department of Xiangfan Prefecture, cannot get paid on time (Lu 2004). Besides taking the form of payment arrears, local governments could also reduce or stop expending on local infrastructures, and so on, which would result in more serious consequences of underprovision of public goods and services. It is reported that local governments deregulate those local key schools, and let them behave like a monopoly and charge high tuitions. In doing so, local governments shake off part of the expenditure responsibilities on education. But the consequence is higher tuitions and lower enrollments, which is obviously an inefficient outcome and also not in the local residents' interests.[19] It is also acknowledged that in order to shift the risks in the revenues, local governments charge higher user fees for the public utilities they own.

[19] The case in Jianli County, Hebei Province that we mentioned earlier provides us an example. Also another example is from the author's fieldwork done in the Henan Province, China, in 1998.

These examples show that the local governments can shift some of the risks in their revenues to the residents or other economic agents within their jurisdictions. That is why risk issues should be considered explicitly in the current tax system. Besides direct regulations, two methods can be followed to help the local government to deal with the risks. The first one can be done through a transfer system managed by the center. Obviously the revenue accrued to the center is more stable than those of the locals because the center collects revenues from the whole country and has a more diversified tax base. The transfer fund can be delivered from the center to different provinces according to different formulas and from provinces to city or prefecture and county governments following some different arrangements (Martinez-Vazquez and Zhang 2002). However, since the formulas highly depend on the provincial governments' capabilities of negotiating with the center, the provinces that need support most are generally those that are poor and have weak bargaining power. Therefore usually the poor provinces are not necessarily able to obtain the support they need through the transferring system. Same phenomena are also observed when the transfers are allocated by the provincial governments to lower level governments.

Alternatively, assigning a more stable tax base to the local government can reduce the risks. Property tax, imposed more on relatively immobile properties and therefore provides government relatively stable revenue sources, is widely used as the tax base for local governments in developed countries. In contrast, the VATs and the agriculture tax that are widely used as major revenue sources for provincial and county governments in

China, fluctuate with the economic conditions and natural conditions respectively, and thus involve risks and can not guarantee to provide stable revenue. Before the adoption of property tax as major local government revenue source, what should be done is to stabilize the current tax base in order to reduce the risks involved.

Since infrastructures play a vital role in mitigating volatility of weather and stabilizing agriculture production, the problem of fluctuations is more serious in areas where infrastructures themselves or their maintenance are in great need. However, due to the nature of the head tax in current rural China, the necessity of stabilizing the tax base is not so urgent, which partly explains why county and township governments, whose major revenue source is agriculture tax, have no incentive to invest in infrastructure. Nonetheless, too much variation is by no means a good thing, thus reducing the variability of tax base should be within every level of governments' policy agenda.

Fourth, the public goods that we are considering here are generally not merely consumption goods, but more importantly, are inputs for production, such as irrigation facilities including reservoirs, dams, and transportation system including roads, bridges, etc. Unlike other infrastructures that mostly bring benefits to households, such as parks, health care facilities, these infrastructures are also conducive to production. In this sense, the government behaviors of public goods provision are closely related to economic growth. That is one of the reasons that it is of great importance to examine the role of government in public goods provision in the context of economic growth of China.

From the above analysis we can see, the current tax system in China suffers from a series of incentive and risk-sharing problems. These problems make the system less efficient than it could be.[20] If we consider this "constitution" a contract between the central and the local, just like contracts binding a landlord and a farmer, these problems can be easily discerned. And it will not be too difficult to remedy these flaws. Keeping this in mind, we are trying to apply the principal-agent model and suggest some mechanism to correct the inefficiencies in the current system.

In order to evaluate alternative systems, it is necessary to undertake positive analysis of how the current system works. Here we take rural China as an example, investigating how the current agriculture tax system works inefficiently and suggesting ways of correcting for it. The reason for choosing to carry out only theoretical analysis in this section is due to the difficulty of obtaining relevant data, which makes it impossible to perform empirical analysis. In addition, the relative simplicity of the agriculture tax in China makes it easier to model the relationship between central government and the local governments. Here we need to specify local governments as county and township governments, for whom agriculture tax comprises one of the most significant revenue sources. More importantly, the agricultural sector in China is the most fundamental economic sector. The majority population in China, the country with the biggest population in the world, consists of farmers, who are generally low income earners, and the task of getting the farmers ends is by itself formidable. According to the Chinese

[20] For this perspective, Gordon and Li (1997) follow the same logic as Wong.

yearbook, in 2001, among the almost 1.3 billion population in China, the rural population took up almost 770 million, a share of about 60%. Following the process of urbanization, this share has been declining from over 80% in late 1970s, but still takes up a bigger share than the urban population. The county and township governments take on a more active role in rural China, which makes it a better object in studying government behaviors.

Agriculture Production and Local Government Behaviors

Agriculture is one of the most important sectors in the Chinese economy, though it is not contributing the most to total GDP. Most of the rural residents are making their living by conducting agricultural activities related to land. This suggests that land is the main financial resource for most of the farmers. What is more, for some of the farmers, the land may be the only chance by which they can make their families' ends met. Even for those new immigrants from countryside to urban areas, the land is of high importance, since most of them take only seasonal jobs in urban areas. What they earn are just top-ups to their agriculture earnings. In addition, their jobs are full of uncertainty. Therefore, the agricultural activity is still the center of the family issues and agriculture production levels are very important for the farmers.

The Chinese rural economy is different from the agriculture industries in the western countries, since the latter are in general intensively capitalized. The agriculture sector in China is characterized by three stylized facts. First, the majority of farmers in China can only conduct agriculture activities on very small pieces of land, located

diversely around the village they live.[21] The average land each farmer is entitled to operate in a county in Hebei province is only 0.07 hectares (Xiang and Huang 2003).[22]

Second, the majority of lands are located in areas very sensitive to the changes in the weather and other natural conditions. Because the irrigation facilities are not generally available, for some batch of land, the production has to rely mostly on the natural precipitation. According to Xiang and Huang (2003), in Hebei province, the mean value of areas could be covered by the irrigation facilities is only 65% with a range from 13% to 95%. Also, in the same province, the surface water resource is only 10% of the national average and 70% of irrigation depends on underground water source, which cannot be easily accessed without considerable investment on irrigation facilities (Xiang and Huang 2003). The water supply in per capita terms in China is less than one quarter of the world average, which makes it imperative to construct infrastructures for water such as dams and wells, etc in the rural areas and develop water-using efficiencies (*Project of China's Agenda 21*). Empirical studies illustrate that the infrastructure is helpful for the improvement of agriculture productivity. For example, even in Jiangsu Province, one of the provinces endowed with the most desirable climate for agriculture activities, evidence shows that investment on infrastructure is very helpful and very important to the increase in agriculture production (Wang 2003).

[21] The reason behind this arrangement is to balance the gain from risk-reduction and the loss caused by diseconomies of scale.
[22] 1 hectare equals 2.471 acres, which makes the average land a farmer can operate to be 0.17 acres.

The third fact is that, as mentioned above, the quantity of farmers in a village is usually very large. It is well known that it is usually difficult to reach an agreement in a big group. In this context, it would be hard to agree on the size of the public goods to be provided in villages by negotiating among farmers in some areas. Due to the high transaction costs involved in reaching an agreement on private provision of infrastructures, the incremental productivity gains from investment in the infrastructures will be reduced.

The interaction of these three factors makes it clear that, without government intervention, the extremely high transaction costs of providing public goods privately will become a big obstacle in making decisions on investing on infrastructures that play such important roles in agricultural production. Lack of government intervention leaves public facilities in rural China mostly unattended. For example, the irrigation facilities in China have been in need of maintenance since the decentralization of the collective economies (Cheng and Chun 2003).

From the above analysis, the government interventions on infrastructure provision could be both beneficial and desirable.[23] The problem is how to finance the

[23] In addition, the public intervention can play a significant role in the anti-poverty in the Chinese rural area. The most part of the Chinese rural communities have been suffering from poverty for a long time. In most rural areas, the basic income sources are still proceeds from farming activities that highly depend on the weather conditions. The consumption risks in the rural area in developing countries such as China are notoriously related to the natural conditions. A lot of non-market institutions have been developed to deal with the risks. Without perfect insurance market, the households can take other actions, some time at very high costs, to avoid the risks they face. These actions can take such forms as crop and field diversification, engagement in other non-farming activities, etc. They “might also limit income risk by choosing a diverse portfolio of occupations, or through the strategic migration of family members” (Alderman and Paxson 1994). In combating risks, the households can be made better off by the informal arrangements such as state-contingent transfer, support between families members, friends, etc (Besley 1995; Morduch 1999; Morduch 1995). The various efforts taken by the households, however, may not alleviate them from poverty

investment. Given that the local governments are of Leviathan type and that governments play important roles in infrastructure provision in the rural areas in China, carrying out a positive analysis of tax structures within this context can better serve our objective of studying tax structure and government behaviors.

Some General Descriptions about Chinese Agriculture Tax

Before getting into insightful analysis, it is necessary to make a plain picture of the agriculture sector in China. Unlike provincial and prefectural governments' enthusiasm of raising revenue by expending more on such infrastructures as roads and so on that we discussed before, county and township government officials seem to have had little interests in local infrastructure construction in rural China. The investment related to rural production has exhibited systematic decline, especially when there is a decline in the revenue pool, like what happened after the fiscal reform hardened the budget constraint for local governments. One of the case studies conducted in Shaanxi Province, one of the poorest in China, unveiled that the pressure of fiscal self-sufficiency resulted in the under-provision of public goods in favor of maximizing revenue instead of social welfare. Therefore, the rural productive investment fell from 8.6% in provincial consolidated expenditure in 1983 to as low as 1% in 1992 for one county, and a dramatic downtrend was witnessed in another county in northern Shannxi, where the same

(World Bank 2000). The resources the households can utilize are limited. For example, though non-farming activities are important to reduce the risks, the household may not have the necessary knowledge or lack of minimum capital to do so (Dercon 2001). As far as the Chinese rural communities are concerned, as mentioned earlier, the poor families' incomes are very sensitive to natural conditions and therefore involve high risks. In this context, government intervention can be further justified by attacking poverty in rural areas.

category of investment fell from 20% in 1980 to only 2% in 1992. Over the same period, the share of mandatory expenditure on education and health remained stable, and the share of wage and subsidies even increased for the first county (Park et al. 1996). As we mentioned before, these seemingly contradictory behaviors are in effect due to the same reason, namely, the pursuit of revenue. What is different in rural China is that it reflects the other side of the story, where county and township government officials try to limit activities that are not conducive to revenue increase, in order to reduce expenditure.

In China, agriculture has been contributing disproportionably more to the industrialization ever since the foundation of the People's Republic of China.[24] Chinese farmers, even though constituting the biggest population group in China and probably working in the hardest conditions, have been in a disadvantageous position relative to all other groups, mainly due to the central government policy bias towards industry. At the beginning of the newly founded republic country, the agriculture tax was not a big burden to the farmers. However, besides the agriculture tax, farmers usually were required to sell grain at a price lower than market price to the state, thus paying a tax implicitly. This compulsive grain procurement policy in the early era of PRC laid heavy burden on farmers. Despite the subsequent economic reforms that changed the agricultural policies now and then, and the calls for alleviating burdens for the farmers, the changes being made had been very marginal. Not until 1979 when the Household

[24] In fact, Chinese farmers have historically been subject to various taxes and charges. In some dynasties in Chinese history, the burden to farmers was so heavy that farmers revolted against the governor.

Responsibility System (HRS) was introduced was farmer's situation actually improved. The slogan for the HRS was that after meeting the requirements of state government and collective units, the remaining part of the grain production is left to the farmers' full discretion. This gave farmers great incentives to engage in grain production. As a consequence, the agriculture productivity has been greatly improved, which makes it possible that a lot of agriculture labors were liberated from the land and subsequently, the rapid development of township and village enterprises (TVEs).[25] This, along with the great efforts farmers put into the land due to the incentives that the new policy brings about, results in the significant increase of farmers' income. Not only was the farmers' living standard greatly improved, but the development of TVEs also contributed a lot to the high economic growth rates since late 1970s, which attracts attention from the whole world. Since infrastructure construction is good for the development of TVEs and also the increase of grain production, even the lowest level of government, the village had the incentive to mobilize resource and expend on infrastructures.[26] The agriculture tax has been stable over time and apparently not a sufficient resource for the infrastructure investment. In consideration of this, county and township governments were "allowed" to collect other non-tax revenue as supplementing resource, which gave rise to a variety

[25] TVEs refer to the township and village enterprises. In the Law of Township and Village Enterprises, TVEs are defined as any enterprises located in the rural area and funded by the collectively owned rural economic organizations or rural residents to engage agriculture-related economic activities. During 1978-1994, in term of the gross value of industrial output of TVEs, the average annual growth rate reached 22.9! And in 1994, the output took up 42% of the whole country (Wu and Cheng 1999). They not only contributed significantly to income increase of rural households and the economic growth in China during the past twenty years, but also provided vast employment opportunities for rural excess labor force.

[26] The village level "government" is not among the formal five-level government structure, and it is more like a government branch that is responsible for the township level government.

of user fees and surcharges imposed on farmers.[27] Meanwhile, without specific expenditure assignment, the central as well as higher level governments tended to shift expenditure responsibilities downwards, which added to the demand for revenue resources. As time went on, local government officials' revenue maximization behavior began to push the situation out of control. They began to impose more and more fees and surcharges, in the names of providing some local public goods, many of which are not needed by farmers, but are in the interests of the local officials' pursuing political benefits (Zhou 2000). More importantly, especially in rural areas, these levies are usually mandates of the county and township governments. Even though without grounds, farmers have to try all means to pay for them, since these kinds of activities are backed up by the cohesive power of government authorities. In the extreme cases, when the farmers cannot hand in the taxes and levies, either due to the lower production resulting from poor natural conditions, or due to the cash shortage resulting from serious health problems, county and township governments would take away their production materials, livestock, or some other consumption merchandise to serve as their payments.[28] Therefore, as far as agriculture tax is concerned, the tax proceeds to the corresponding governments can be taken as fixed and are guaranteed.[29] County and township

[27] Of course, local governments are not formally, legally allowed to do so. Central government is not so restrictive in enforcing the regulation, which gives local governments some discretion to collect those fees and surcharges.
[28] The rural residents in China are in disadvantageous in many aspects relative to urban residents; the lack of health insurance is one of them. Therefore, if farmers encounter some major disease, they have to pay all the expenses out of their own pockets, which either become a big burden for several years thereafter if they can borrow money to pay for the bills, or they simply cannot afford to get treated.
[29] The conducts of capturing from the farmers is actually sometimes implemented more by the village level "government", instead of directly by the county and township governments. However, it is with the consent or even the pressure from the higher level governments.

government officials had no incentive to improve infrastructures in order to improve agriculture production, since the increase in production level will not preserve or enlarge revenue base, different from the case for VAT.

The decline in infrastructure investment has been a relatively recent phenomenon. Historically, in the Mao era, there was huge investment on the irrigation system in rural areas. At that time, the government could deploy a labor force in some area without paying much out of the budget. By improving the infrastructures that are beneficial to agriculture production, which was under the government's direct control, the government could extract more food and produce resulting from the higher production level. (Lin 1988).

In the post-Mao era, however, the investment from government declined significantly. According to the calculation based on data from the report by the International Food Policy Research Institute (IFPRI) and Statistic Yearbook of China (China statistical yearbook 2004), the ratio of public investment over total investment in the agriculture sector in China was 17 % in 1980. In 1997, this ratio declined to 10% (Fan, Zhang, and Zhang 2002). Huang and Roselle (2002) found that the ratio of government agricultural expenditure over agricultural gross domestic products (AGDP) declined from 7.6% in 1978 to 3.6% in 1985. In addition, the public expenditure on the water system decreased significantly. For example, in the "Fifth five – year Plan" period (1976-1980), the ratio of public expenditure on water system over total government

expenditures was 5.7%. The same ratio in 1993 was only 2.4% (Chen and Yang 1998). The declines of the public expenditure in rural areas have caused serious problems.

The evidence documented above is inconsistent with economics theories. In general, public goods are normal goods in that as income level increases the demand for public goods should increase; the public infrastructures should follow this trend. However, we see a totally different picture here. Evidence told us that when the income level was low, the Chinese government invested heavily on infrastructures in rural area. It is unmistakable that Chinese economy has been growing fast for the last 20 years; and the corresponding income effect should push up the demand for public goods. However, the real investment in infrastructures has been declining. This mismatch between income level and public goods provision might be explained from some special angle. From our point of view, part of the answer maybe lies in the current agriculture tax structure in China. Therefore, we need to take a closer look at the agriculture tax system.

The current agriculture tax in China is essentially a fixed rent. In China, the individual farmer has become the basic tax unit ever since the decentralization of the collectives. The amount of agriculture tax a household pays depends on the units of land the family is entitled to operate, and is not based on the amount of agricultural products being produced and transacted on that land.[30] In general, all people in the same village share the land equally. The equality of land allocation means that all people have the same taxable units. Under this arrangement, an infant and a 90-year-old have the same

[30] In China, the property right of land belongs to the country. Land is allocated to farmers based on some egalitarian rule so farmers can use the land they are entitled to.

tax liability as a working laborer. Therefore, the agriculture tax is actually a head tax (Liu 2004).[31]

More importantly, the tax for each unit of land is fixed. According to the Regulation of Agriculture Tax Collection of PRC, the tax collected from land is based on the average of production in a period of time.[32] This is justified in terms of savings in transaction costs. Indeed, in such a big country the transaction cost will be extremely high if measuring the real production of different batch of land with various outputs throughout of the year and collecting tax accordingly. The self-finance nature of Chinese farmers makes things even complicated.[33] In fact, even under current regulations, the administration costs are already very high compared to the revenues that can be collected. According to the governor of Hainan Province, Liucheng Wei, the total agriculture tax revenue in Hainan Province in 2003 was only 50 millions Yuan.[34] The administration cost was 20 million Yuan, which means that 40% of taxes collected went to the operation of tax collection agencies (Zhang 2004). This is astonishing compared with statistics in other countries. For example, the average tax administration cost in the United States was

[31] According to the agricultural tax code, the agricultural tax is a proportional tax. The amount payable equals the product of the taxable land area, the applicable average tax rate and the production per unit of land. Among these three parts, the production per unit of land is the production based on fair land cultivation and normal natural conditions per unit a land. It is usually some average level of production, not the actual production in a given year in a particular batch of land. Once chosen, it will be fixed and applied to any batch of land in the village for several years. The applicable average tax rate in each county is usually determined by the provincial government and applied to the entire population of farmers in the county. The rate stated in the agricultural tax code is 15.5% (Liu 2004). However, it has never been this high in implementation, and has been decreasing in recent years following the policy orientation of the central government. In actual collection, however, since the area of land each farmer is entitled to operate is basically equalized, the agriculture tax is the same for everyone in the village. That's why we take it a head tax.
[32] This is verified by my interview with the Head of a village in Henan Province.
[33] It is well know that Chinese farmers have a tradition to support themselves mainly out of their own production.
[34] To give an idea how big the figure is, the current exchange rate is 1 dollar = 8.3 RMB.

only 1% of the tax revenue, which means for per 1000 tax dollars collected, expenditure on tax administration was only 10 dollars.[35]

Serious efficiency problems arise due to the fixed head tax. The system shifts all risks to the farmers. Because the government is in a better position to deal with the risks than individuals, there is inefficiency in term of risk pooling. What is more, since the rent is fixed, any additional expenditure by government on agriculture will be irrational. Thus the current tax system gives local governments little incentives to invest on agriculture, except maybe, when there is a reassessment after a period of time. The efficiency problem is exacerbated by the fact that the agriculture production highly depends on the natural conditions, which, in turn, crucially depends on the government investment behavior on infrastructures.

The solution to this kind of problem often lies in the rule Buchanan and Brennan proposed, what we called the B-B rule earlier.

The B-B Rule

The most difficult problem for the Leviathan model is that it cannot be easily tested in western economies. For example, suppose the local government allocates some funds in constructing local roads. These roads surely bring benefits to the local voters and the local business. For these kinds of government behaviors, however, it is difficult to differentiate whether it is due to the pressure of re-election, or simply the consequence of government's revenue maximization. To solve this problem, following what Brennan

[35] Please refer to footnote 4 on page 9.

and Buchanan did in their paper, the assumption that budgetary revenue and expenditures are determined by the median voter's preference at postconstitutional period can be dropped; therefore, "individual voters-taxpayers exert control over the fiscal system only at the constitutional stage; they are essentially powerless to affect the government's fiscal activities in postconstitutional political settings" (Brennan and Buchanan 1978). Under this condition, Brennan and Buchanan suggest a particular form of earmarking, so "each expenditure is allotted a particular tax base that is highly complementary with the public good itself" (Brennan and Buchanan 1978). Brennan and Buchanan want to use the complementarities to constrain the behaviors of Leviathan-like governments. That is what we call the B-B rule.

B-B rule is a good starting-point to solve the incentive problem inherently related to the behaviors of government. This rule links the interests of voters and those of the governments. Since the voting mechanism is assumed away, the government does something good from the perspective of voters, not because the government cares about the voters, or has altruistic preference. Instead, the benefits that voters gain are the by-product of government's selfish behavior of utility maximization. For example, the local governments may take some actions to protect the environment. This behavior is not motivated by catering to voters' interests, as predicted by the Median Voter Hypothesis, but to protect the governments' tax bases. According to the current tax "constitution" in the United States, most of the local governments highly depend on the property tax as their revenue sources. Since there is a negative relationship between the

pollution level and the values of the properties, which in turn are the tax bases; protect the environment is in fact to protect the tax base (Glaeser 1995). Similarly, central governments take some actions to protect environments, again, not because they care about voters' health; but because higher pollution level will make people unhealthy and raise the possibility to pay higher health care bills, which in turn, will lower a Leviathan-like government's space to manipulate the tax revenues. This is a point that we are going to analyze in more detail in the second essay.

The applications of B-B rule are limited, however. Some surprising outcomes may be derived from this type of optimal design analysis. For example, levying tax on education may be efficient. This is of course, not the case in term of normative analysis of public finance. But for a Leviathan-like government, spending money on education is surely not optimal because, in most countries' tax regimes, education sector does not produce any immediate tax revenue.[36] The government will not have incentive to "invest" on education sector unless it is required to do so in the "constitution." According to B-B rule, a necessary step, however, to induce instead of force government to "invest" on education is to grant government the power to collect taxes from education. Under this condition, the expansion of education sector is conducive to revenue growth. The government thus has incentives to "invest."[37]

[36] That's exactly why the situations described in page 11-12 happen.

[37] This taxation can be justified by the following way. There may be some efficiency loss caused by taxation. The society, however, may gain from the enlarged education production. The net effect could be positive. Of course in this way government is acting myopically if we take into account that education can contribute to economic growth and therefore bring about more taxes in the future. Nonetheless, it is different in China in that people cannot move across regions freely, since regional migration is restricted in China.

The above discussion shows that applying B-B rule to solve the incentive problem does not take into consideration risk sharing, which may result in inefficiencies. Thus it may not offer an ideal solution to solving the incentive problems behind the behaviors of a Leviathan-like government. Keeping this in mind, we should discuss the incentive issues in a more restrictive manner, taking into account the risk sharing in order to get a constructive outcome.

As we noted earlier, the risk issues in the Chinese fiscal system should be given special attention.[38] The vertically accountable political structure does give central government the power to modify the behaviors of local government by issuing more regulations, however at the expense of high enforcement and monitoring costs. For instance, the salaries of teachers are now guaranteed by regulations from the central government, as a response from the central government to the huge delays for the payments to teachers across the whole country, which resulted in serious grievance from teachers and even closedown of some elementary schools and middle schools. This regulation from the central government did make a difference: in the subsequent years, such delays never explicitly happened again.

On the other hand, however, more regulations are not necessarily a good solution. For whatever "constitution," since it is impractical to exhaust all the possibilities, the governments will always have opportunistic behaviors, let alone the enforcement and monitoring costs involved. It is possible to regulate the payment schedule of teachers'

[38] We analyzed the risk issue in more detail in previous part. Please refer to page 36.

salaries in a “constitution,” but it will be difficult to monitor the behaviors of local key schools that charge student high tuitions. These strategic behaviors taken on by the local governments, as we analyzed earlier, are most likely to benefit the governments themselves, and hurt the residents in their jurisdictions. So it is necessary to consider the risks related to the revenues of local government in a “constitution” in order for the local government to behave desirably. Therefore, the principal-agent model which deals with both incentive and risk sharing should provide us a good choice.

In a principal-agent model, there are two parties; one is the so-called agent, and the other is the so-called principal. This framework has numerous applications. In general, it can be used to analyze any situations in which one party’s behaviors can affect the others. The agent is assumed to have some informational advantages compared to the principal. For example, in a firm, the employees’ efforts can affect the productivity and in turn affect the interests of the owner of the firm. The owner cannot observe the effort levels exerted by the employees, and can only observe the resulting production level. Meanwhile, the production level is often assumed to be affected by some random variables neither observable nor controllable, which makes it impossible for the owner to infer the employees’ effort levels based on the production level. Therefore the principal-agent model usually tries to construct some payment schedule in order to induce the employees to exert higher effort levels, under which the possibility of achieving better production is higher. If the employees are paid at a fixed wage, they may not have incentives to work hard. On the other hand, as far as risk sharing is concerned, it

may be efficient to offer workers fixed wages, since compared with the individual employees, the firm is in a better position than the individual employees to deal with risks. So there is a potential conflict between the risk sharing and incentives (Holmstrom 1979; Pauly 1974; Ross 1973; Shavell 1979).

Essentially, the key issue in the relationship between the government and voters is that voters cannot observe the government's behaviors directly, or cannot control the behaviors at the after-constitutional stage. For the Leviathan-like governments, if we do not give them incentives to do what we expect them to do, as B-B rule discussed, they will spend a minimum on what they are supposed to do at the after-constitutional stage. That is why the optimal constitution design can be better discussed in a principal-agent model, in addition to the earmarking as suggested by B-B rule.

We are going to extend B-B rule in the following ways. We first keep the assumption behind the B-B rule that a voting system does not take effect in the post constitution stage. That is why we take China, where no election exists, as an ideal case to analyze the behaviors of a Leviathan-like government. Second, we incorporate production function into the initial framework. We want to achieve efficiency gain in production by showing how government behaviors affect the production, and in turn affect economic growth. While the B-B rule does not consider the risk-sharing issue explicitly, we will analyze the interaction between the incentives and risk sharing in a principal-agent framework.

The Model

In this section, a very simple model will be developed to show how the current tax structure works inefficiently. In a later section, we will try to design a very simple mechanism to achieve more efficient outcomes.

In the current Chinese agriculture tax system, we assume that, first, the local governments are Leviathan-like governments. For the purpose of dealing with agricultural tax in our model, we are going to deal more with county and township governments here. For ease of notation, we will label them local government. As we discussed earlier, even under election pressure, governments may have strategic behaviors. Without elections, the government is most likely to behave like a Leviathan. The Chinese local governments do not care or care less about the interests of local residents because there is no horizontal accountability. The only constraints are from regulations issued by the central.[39] To be consistent, we call the regulations "constitution." The central government is assumed not to be able to control the local governments once the "constitution" (regulation) is issued because of the asymmetric information problem.

Second, we assume that the central government cares about the interests of farmers. The role of central government is analogous to that of the legislature in the western countries. To some extent, it seems reasonable to make this assumption.

[39] There are at least provincial governments and prefecture governments between the central government and the local governments that we use here. However, the two levels of government either collaborate with the lower level government in the collection of agriculture tax, or take the stand of the central. Therefore we assume them away in the construction of our model. Even though it will lose certain merits because of this simplification, we believe that it won't affect the essence of the problem we are going to deal with in this section.

Compared with the local governments, the central government does care more about farmers. At least the central takes a neutral stance and is trusted by the farmers. One of the explanations is that the central government wants to keep the regime stable. Also, the central government may want to keep some balance between local officials and the residents. Actually, dealing with the dishonest, or, in some context, even illegal, conducts of the local governments is one of the most important tasks for the central government and entails a lot of resources. If sometimes the local governments' bad behaviors are pervasive across the country and serious in consequences, the central may enact new regulations, orders and documents, etc., to solve the problems. During years when the local governments go beyond limits in abusing their authority and taxing farmers excessively in the rural areas, a lot of farmers go to the central government agencies and petition for the problem to be solved. For example, in 1990s, the local governments in Anhui Province levied excessive taxes on the farmers, which broke the guideline issued by the central and put many farmers in misery. The farmers tried to repeal the excess taxes by writing to the central government, or visiting the State Council in person. Almost every time, the central government took some actions to discipline the local governments and alleviate the burdens to the farmers (Cheng and Chun 2003).

Third, we assume the central is in a better position to deal with the risk issues. This assumption is reasonable. China is a big country with a fairly diversified geographic and demographic pattern across the whole country. Since the local governments can only collect taxes from their individual jurisdictions, the taxe bases in a specific region are

more likely to suffer from some idiosyncratic risks. The central, however, can collect taxes from the whole country; therefore, its tax bases may be less likely to suffer from those risks. It is fair to say that the revenue of the central is less risky than those of any single local governments. From this aspect, we can assume that the central government is less risk averse than the local governments.

Fourth, we assume that the public sector has a key role to play in the agriculture production. First, evidence shows that, even in the most fertile regions, such as Jiangsu Province and Zhejiang Province, the infrastructures still play an important role in the agriculture production.[40] In this context, reaching an agreement on constructing some infrastructures is surely Pareto improvement. This agreement, however, cannot be achieved easily. The potential transaction costs to reach an agreement among a big group of farmers are high. One better option is to induce the government to play some role. The efficiency can be achieved by allowing government to levy tax in exchange for supplying some public goods.

In our model, we assume the central government will act completely on behalf of farmers.[41] The term "farmers" and the "central government" will be used interchangeably. Following the classic principal-agent model, the farmers, taken as a group, also represented by the central government, can be modeled as the principal (Holmstrom

[40] For details, please refer to previous section, page 42.

[41] There are some points related to this assumption that need to be clarified. The individual farmer may be even more risk averse than the local government. Imagine however, within such a context, the central government can allocate some subsidies to the farmers, and can thus share the farmers' risks. Besides, the infrastructure is shared among many farmers, such that as a group, the farmers can pool some risks. The local government, however, cannot shift out risks and therefore is more risk averse in this sense.

1979).[42] The farmers' production depends on the public goods supplied by the local government and a random variable including weather and other natural factors that cannot be controlled by human behaviors.[43] For example, the dams may not be useful if the weather is good; the pest-control makes no contributions to the production in a year when there are no pests. However, the dams will have a key impact on the production level if there is a draught or a flood, and the farmers will need the pest-control badly in a year when the pests become a serious problem. The production level would be extremely low without the dams or the measures taken by the governments to control pests.

Since the public goods supplied by the local governments will directly affect the production levels, and these kinds of behaviors by local governments are not observed directly by the central governments, we are going to model the local government as an agent whose behaviors affect the interests of the principal, the farmers. Even though the farmers can observe the level of efforts by the local governments in providing public goods, it is very difficult for the farmers to deliver the information to the central government. Besides, there exist some factors that are not observable or not verifiable by the farmers, which are captured by the random variable that we mentioned earlier. Therefore, the central government, as the principal, cannot easily discern whether the lower production level is due to the delinquency of local governments, the agent, or bad natural conditions. Plus everything is locked into the "constitution" at the start.

[42] Our model is essentially an application of those models in Holmstrom (1979).
[43] Originally we included the labor as an input, but the labor doesn't play any role in this model, so we took it out.

Assume the farmer's production function is: $x = x(a, \Theta)$, where x is the production level for a given batch of land, a represents the level of public good provided by local government, Θ is the random variable capturing weather and other natural factors that we discussed above.[44]

Imagine there is a governor newly appointed by the central government. When he takes the office, there are some revenues collected from last year's economic activities. These revenues can be used to compensate for the costs in the public sectors such as educations, fire stations, outlays, dams and so on. Following our discussion earlier, we assume that he is a Leviathan-type official. Also, we assume that in his jurisdiction, there are only two economic sectors, one is agriculture, and the other is non-agriculture. The governor cannot make any decisions on the legal coverage of the tax bases and tax rates. The central government, however, cannot control perfectly the governor's expenditure behaviors. In other words, even if the central government can issue mandate on how much the governor should allocate to education, health system, and etc., the actual allocations of funds are highly dependent on the local governor's incentives, due to the high monitoring cost.

We assume that the local government has the following revenue function: $U(t, a) = v(t(x)) - c(a)$. It takes this additive form, in order to illustrate conveniently the fact that the local government derives utility from the tax revenue while

[44] Or, alternatively, a can be interpreted as the level of public goods provided, under good governance.

incurs disutility from providing pubic goods.[45] We assume that $v(t(x))$ is strictly concave in $t(x)$, in order to capture that the local government is strictly risk-averse, compared with the central government, which is assumed to be risk neutral for simplicity. In the revenue function, $t(x)$ is the tax revenue collected from agriculture sector when the production is x, and $c(a)$ is the cost of providing local infrastructures under effort a, such as on irrigation system, roads, dams, wells and so on.

To capture the effects of the moral hazard problem, we need to specify the model in more details. The agent, the local governor, can choose from two effort levels of providing public goods, $a \in \{a^h, a^l\}$, where a^h and a^l represent the high and low effort level respectively. For the agent, the cost for low-level effort is $c(a^l)$; the cost for high level is $c(a^h)$. We assume that $c(a)$ is an increasing function of a, so we have $c(a^h) > c(a^l)$.

To capture the relationship between the production level and the public goods supplied by the local governments, we need to assume that *x* is F.S.D. of *a*.[46] This assumption states that a higher a will increase the possibility of obtaining higher production, while at a higher cost, though.

To capture the effects of the random variable on the production level, we need to assume that the output is determined stochastically. The output variable x can only take

[45] Or, to put in another way, spending on public infrastructures that are not conducive to the tax revenue increase is actually a subtraction from the utility resulted from the higher fiscal resource at discretion, therefore is not in the interests of the local officials. In this sense, we have this disutility term here.

[46] *x* is first order stochastic dominance of *a*, meaning that other things equal, with higher effort level, the probability of achieving higher production level is higher than with lower effort level.

two discrete values, namely $\tilde{x} \in \{x^h, x^l\}$. What is more, to model the random feature of this problem, we further assume that, there is a possibility that the two levels of government efforts can lead to the same level of output.

Because the effort chosen by the agent cannot be observed directly by the principal, it is impossible to levy the tax according to the effort level a.

In this context, if the agent's effort level is a^h, then there is a higher probability to reach the higher production level x^h. We assume with a^h, the possibility to get x^h is p_1. Meanwhile, a higher-level effort a^h cannot guarantee the achievement of x^h for sure because the production level is determined stochastically. Still we have some possibilities to reach x^l. In this case, we assume the probability of getting x^l under a^h is $(1-p_1)$.

In this model, a lower-level effort a^l supplied by the local government does not mean a lower-level production x^l with certainty, either. It might be due to extraordinarily favorable natural conditions. Because of this possibility, with lower-level effort of supplying public goods, the farmers still can obtain good harvests. Of course, the chance of getting x^h with a^l is lower than that with a^h. If the agent's effort level is a^l, we assume that the probability we get x^h is p_2, the probability we get x^l is $(1-p_2)$. Apparently, we have $p_1 > p_2$ hold. Then we have the following figure.

Figure I Probabilities of High and Low Efforts

	$X = x^h$	$X = x^l$	Total Prob.
$a = a^h$	p_1	$(1-p_1)$	1
$a = a^l$	p_2	$(1-p_2)$	1

We know that the farmer and the central government always prefer higher-level output, and with higher effort level it is more likely to reach higher production level, therefore, the central government will try to induce local government to provide a^h. To do so, the only way for the central government is to design a "constitution" at the before-constitution stage. At the after-constitution stage, the central does not have effective means to control the local government. The "constitution" may work by assigning possibly different taxes for different levels of output. The link between agriculture production level and government's revenue may give local government some incentives to exert higher-level effort.

To make the problem easier, we define $t(x^h)$ as the tax collected when output is high, and $t(x^l)$ as the tax collected when output is low. We assume that, if the central government does not allow the local government to levy tax on farmers, the government will not have incentive to supply public goods. The governor will "invest" on the nonagricultural sector. By doing so, they can collect some fixed amount of taxes, which is the reservation revenue, $\overline{m}$.

Also, we define the following time path. First, the central government issues the "constitution," which can be a tax law or regulation such as $\{t(x^h), t(x^l)\}$. Second, local government may accept or reject the regulation.[47] Thirdly, the local official provides certain level of effort. Fourthly, the random output x is produced. Finally, by law or regulation, the tax will be collected.[48]

Based on the classic model of moral hazard, we have the following program. First, the agent's individual rationality should be satisfied. The agent should earn at least higher than his reservation revenue, $\overline{m}$. Second, the agent's incentive compatibility should be satisfied, which means that he has the incentives to offer higher effort. In other words, his utility of exerting higher-level effort a^h will be at least as high as the utility of exerting lower-level effort a^l.

The local governor's expected utility from exerting higher-level effort a^h is:

$p_1 u(t(x^h)) + (1 - p_1)u(t(x^l))$, or $p_1 v(t(x^h)) + (1 - p_1)v(t(x^l)) - c(a^h)$.

The expected tax revenue from a^l is: $p_2 u(t(x^h)) + (1 - p_2)u(t(x^l))$,

or $p_2 v(t(x^h)) + (1 - p_2)v(t(x^l)) - c(a^l)$.

So the incentive compatibility constraint (IC) for obtaining higher effort is the following:

$$p_1 v(t(x^h)) + (1 - p_1)v(t(x^l)) - c(a^h) \geq p_2 v(t(x^h)) + (1 - p_2)v(t(x^l)) - c(a^l) \qquad (1)$$

The individual rationality constraint (IR) for obtaining high effort is the following:

[47] For example, the local governor can choose to meet only the minimum requirements.
[48] As we noted earlier, the rate of tax collection is an instrument within the local government's full control and can be employed to increase tax revenue. Here for our question in hand, we leave this issue out for simplicity.

$$p_1 v(t(x^h)) + (1 - p_1) v(t(x^l)) - c(a^h) \geq \overline{m} \quad (2)$$

Constraint (1) says that for the agent, the incentive should be compatible, which means that the expected utility from high effort should exceed the expected utility from low effort. Constraint (2) says that, the "constitution" offered should be attractive to the agent. If both (1) and (2) are satisfied, a constitution is said to be incentive feasible.

This is a typical two-stage model. At the first stage, the central makes an offer. At the second stage, for any given offer, the local governor takes actions to maximize his revenue. In general, we can use backwards induction to solve this program. The solution to this program is a sub-game perfect outcome. We first solve the local governor's maximization problem at the second stage. Then we go back to solve the central government's problem given local governor's optimal solution, assuming the central government can solve the agent's problem as well as the agent can do it by himself.

Benchmark

To make a clear comparison between the different outcomes from different "constitutions," we need a benchmark model. In this case, we make a strong assumption that the central government is capable of observing the local government's behaviors completely. In the current Chinese political system, there is only vertical accountability. Therefore, if the central government has full information on local governments' behaviors, the latter would be required to take whatever actions to maximize the agriculture production, which is in the central government's interests.

Let us follow the traditional methods to reach the backwards induction outcome. First, at the second stage, the agent makes decisions. In this special case, the agent cannot make decision according to his own interests because the central can force him to do what the central think necessary. Therefore, we do not need to consider the incentive compatibility. All we need to do is to keep the local government to invest on the rural agriculture sector, i.e., satisfy the rationality constraint. Thus, at the second stage, the local government will exert high or low-level effort, depending on the interests of the central government.

We turn next to the central government at stage one. Given the local governments' response, the central government is going to solve the following revenue maximization problem

$$\max_{\{t^h, t^l\}} w = p\,(x^h - t(x^h)) + (1-p)(x^l - t(x^l))$$

This revenue function is essentially the expectation of revenue under high effort level and low effort level with different probabilities. Since in both cases, the local government collects a tax from the output resulting from different effort level, the revenue in each case is obtained by subtracting the relevant taxes accrued to the local government from the respective outputs.

The revenue maximization is subject to the response of the local government at the second stage, which is $pv(t(x^h)) + (1-p)v(t(x^l)) - c(a) \geq \overline{m}$

The Lagrange is

$$L = p(x^h - t(x^h)) + (1-p)(x^l - t(x^l)) + \lambda[\ pv(t(x^h)) + (1-p)v(t(x^l)) - c(a) - \overline{m}\ ]$$

The Kuhn-Tucker conditions are the following:

$$-\ p + \lambda p\ v'(t(x^h)) \le 0, = 0 \qquad if \qquad t(x^h) > 0 \qquad (3)$$

$$-(1-p) + \lambda(1-p\ )v'(t(x^l)) \le 0, = 0 \qquad if \qquad t(x^l) > 0 \qquad (4)$$

$$pv(t(x^h)) + (1-p)v(t(x^l)) - c(a) - \overline{m} \ge 0 \qquad = 0 \qquad if \qquad \lambda > 0$$

From (3) and (4), we can get the first-best solution. First, λ, $t(x^h)$ and $t(x^l)$ are positive. Then we have the constraints are binding. So we have $\frac{1}{v'(t(x^h))} = \frac{1}{v'(t(x^l))} = \lambda$, and so $v'(t(x^h)) = v'(t(x^l))$. Together with the condition that the agent is strictly risk averse**,** we have $t^* = t(x^h) = t(x^l)$. The risk neutral principal offers full insurance to the risk averse agent. Also t^* is independent of the state of nature.

Since only the individual rationality matters, we substitute the solution $t^* = t(x^h) = t(x^l)$ into local governor's rationality equation. When $t^* = t(x^h)$, from the binding constraint for *higher effort*, we can get for local government,

$$p_1 v(t(x^h)) + (1-p_1)v(t(x^l)) - c(a^h) = \overline{m}$$

So we have $v(t(x^h)) = \overline{m} + c(a^h)$.

Therefore the local government's optimal tax revenue under higher effort:

$$u^*(high) = v(t(x^h)) - c(a^h) = \overline{m} + c(a^h) - c(a^h) = \overline{m} \qquad (5).$$

With a higher effort of providing public goods, the agriculture production *x* could be x^h with a possibility p_1. And, with the possibility $(1-p_1)$, the production level

could be x^l. In both cases, the farmer should be paying a tax $t(x^h) = v^{-1}(\overline{m} + c(a^h))$. So the farmer (or the central government)'s net revenue is determined by the following equation:

$$w^*(high) = p_1(x^h - t(x^h)) + (1 - p_1)(x^l - t(x^h))$$

Or $w^*(high) = p_1 x^h + (1 - p_1)x^l - v^{-1}(\overline{m} + c(a^h))$ (6) .

On the other hand, when $t^* = t(x^l)$, from the binding constraint for *lower effort*, we can get for local government,

$p_2 v(t(x^h)) + (1 - p_2)v(t(x^l)) - c(a^l) = \overline{m}$, which means

$v(t(x^l)) = \overline{m} + c(a^l)$. So the local government's optimal revenue under lower effort is

$$u^*(low) = v(t(x^l)) - c(a^l) = \overline{m} + c(a^l) - c(a^l) = \overline{m} \qquad (7)$$

With a lower effort of providing public goods, the random agriculture production *x* could be x^h with a possibility p_2, and also could be x^l with the possibility $(1 - p_2)$. In both cases, the farmer should be paying a tax $t(x^l) = v^{-1}(\overline{m} + c(a^l))$. So the farmer's net revenue is determined by the following equation:

$$w^*(low) = p_2(x^h - t(x^l)) + (1 - p_2)(x^l - t(x^l))$$

Or

$$w^*(low) = p_2 x^h + (1 - p_2)x^l - v^{-1}(\overline{m} + c(a^l)) \qquad (8) .$$

Because in the benchmark solution, we assume that the central government can observe and control the local governor perfectly, it follows that if the value from equation (6) is greater than that of equation (8), the central government will require the local government to exert a^h; otherwise, a^l will be the central government's policy target.

Therefore, the decision of inducing the agent to exert what level of efforts depends on the values of $w^*(high)$ and $w^*(low)$.

The principal would induce a high-level effort if and only if:

$w^*(high) - w^*(low) \geq 0$, which means

$$(p_1 - p_2)(x^h - x^l) \geq v^{-1}(\overline{m} + c(a^h)) - v^{-1}(\overline{m} + c(a^l)) \qquad (9).$$

In the above equation, $(x^h - x^l)$ is the difference between high and low level of agricultural production. $(p_1 - p_2)$ is the difference between the possibilities of achieving higher level of production under different effort levels. The left hand side of equation (9) can be interpreted as the expected efficiency gain induced by the increased efforts. The right hand side can be interpreted as the agent's cost in terms of the increased disutility resulted from exerting the higher level of effort than the lower level of effort. Therefore, the central government will choose to induce a higher effort if and only if the expected gain from higher effort is greater than the cost.

Alternatively, to see it more clearly, we can rewrite equation (9) as the following

$$p_1(x^h - x^l) - v^{-1}(\overline{m} + c(a^h)) \geq p_2(x^h - x^l) - v^{-1}(\overline{m} + c(a^l)) \qquad (10).$$

The left hand side of equation (10) is the net benefit from the higher effort, and the right hand side is the net benefit from the lower effort. The higher-level of effort will be chosen if and only if the net benefit from the former is greater than that of from the latter. From the society's perspective, in equilibrium, the marginal benefits from higher effort and lower effort should be equal.

When (9) or (10) holds, the local government will be required to exert a^h and thereby collect $t(x^h) = v^{-1}(\overline{m} + c(a^h))$. In this case, the farmer's profit is determined by equation (6), and the local government's net revenue is governed by equation (5).

Alternatively, if equations (9) and (10) do not hold, the local government will be required to exert a^l and collect $t(x^l) = v^{-1}(\overline{m} + c(a^l))$. In this case, the farmer's profit is determined by equation (8), and the local government's net revenue is governed by equation (7).

This analysis shows that the local government receives fixed tax revenue because equation (5) and (7) have the same outcome, $\overline{m}$. The farmer, or the central government's net profit, however, are different. Also, we cannot determine which one is bigger.

To summarize, we have the following proposition.

Proposition I: if the behaviors of local government can be observed completely by the central government, an optimal "constitution" $\{t(x^i), a^i\}$, *where* $i = h, l$, *is that:*

(i), the risk neutral central government offers the risk averse local government full insurance. The local government's tax revenue is independent of local governor's efforts of providing public goods, and therefore is risk free. (ii), since the central government have perfect information and also can perfectly control local government's effort level, the local government's efforts are determined by the farmer's production function and risk distribution. These come to mean that the local government will exert a

first-best level of effort. (iii), the farmer takes all risks.[49] (iv), the outcome is socially efficient in term of first-best.

Some remarks about Proposition I

The choice of optimal effort t^* between $t(x^h)$ and $t(x^l)$ will depend on the nature of the production function and the process of public goods provision. For example, if the public goods are very conducive to the agriculture production, the provision of public good would significantly increase the possibility of *x* to achieve higher level. Then, a higher-level effort would be induced. This case could happen in areas where farmers have high demands on public goods. On the other hand, if the public goods cannot contribute much to the agriculture production, a lower-level effort would be optimal from the social perspective, since it saves on the costs. Therefore, the higher effort may not always be efficient.

In this case with perfect information, there is no conflict between the incentives and risk sharing. In general, incentives should be induced by a self-enforcing mechanism. Typically, we require the incentive constraint be satisfied. Here this constraint is unnecessary. The authorities of the central government, which can observe perfectly the behaviors of local government and thereby control it completely, replace the self-enforcing mechanism.

In this first-best world, the risk-sharing issue can be separated from the incentive problem. The central government takes all risks and leaves the local government no risks.

[49] The risks can be shifted to the central government by programs like price flooring.

This allocation of risks between the two parties is optimal since the central is assumed to be risk neutral, while the local government is assumed to be risk averse.

In addition, this constitution is socially efficient. Since we can separate the risk from incentive issue, there are no disincentives caused by the risk sharing. Also, the grand production frontier could be reached through this tax structure, as for any given resources, we cannot find any other possible reallocation to further increase the agriculture production.

The Moral Hazard Problems—Current Tax Structure and Its Outcomes

Just as mentioned above, the Chinese current tax structure in the rural area by nature is a head tax. Every year, farmers hand in a given amount of money to the local government as the tax. Though the central government does care about the welfare of the farmers, the cost of monitoring local government is extremely high due to the problems related to asymmetric information and bureaucracy. Therefore, in reality the local government' behaviors of providing local infrastructure cannot be monitored effectively.

The current "constitution" set up a fixed tax schedule; therefore all risks fall on the central government.[50] There exists a serious incentive problem because the central government cannot monitor the local government perfectly.

Under the current tax structure, the tax revenue local government can collect is t^{fixed}, which is independent of x and a. Because of this, for any given t^{fixed}, it is

[50] If the risks cannot be shifted to the central government, the farmers will have to take all risks. Unfortunately, the latter is what usually happens in the real life.

rational for local government to exert a low effort because it means a lower expenditure. We can check this very easily.

The revenue from low effort is:

$$u^{fixed}(low) = v(t^{fixed}) - c(a^l) \qquad (11).$$

The revenue from high effort is:

$$u^{fixed}(high) = v(t^{fixed}) - c(a^h) \qquad (12).$$

Then we have

$$u^{fixed}(low) - u^{fixed}(high) = (v(t^{fixed}) - c(a^l)) - (v(t^{fixed}) - c(a^h)) = c(a^h) - c(a^l) > 0,$$

since according to our assumption, $c(a)$ is increasing in a. Thus the local government will rationally choose low level of effort. In the current "constitution," the central government does not provide local government incentives to exert high effort. The incentive compatibility constraint to obtain high effort (1) will not hold. Instead, the local government will get $\overline{m}$, so the individual rationality constraint for low effort,

$$p_2 v(t^{fixed}) + (1 - p_2) v(t^{fixed}) - c(a^l) \geq \overline{m}$$

will be binding, which means

$$p_2 v(t^{fixed}) + (1 - p_2) v(t^{fixed}) - c(a^l) = \overline{m}$$

From this equation, we can get $t^{fixed} = v^{-1}(\overline{m} + c(a^l))$, and

$$u^{fixed}(low) = \overline{m} \qquad (13).$$

At the same time, for the farmer:

$$w^{fixed}(low) = p_2(x^h - t^{fixed}) + (1 - p_2)(x^l - t^{fixed}).$$

Or $w^{fixed}(low) = p_2 x^h + (1 - p_2) x^l - t^{fixed}$ (14).

It is easy to check that

$$w^*(high) > w^{fixed}(low) \quad (15)$$

Since $t^{fixed} = v^{-1}(\overline{m} + c(a^l)) = t(x^l)$, we will have

$$w^*(low) = w^{fixed}(low) \quad (15)'$$

To summarize the effects of the moral hazard problem, we have the following proposition.

Proposition II, the moral hazard problem is related inherently to the current head tax system in rural areas in China. The local government has no incentives to invest on local infrastructures.[51] *This disincentive problem is rooted in the current tax structure or "constitution." The outcome is not socially efficient, and there is room for Pareto improvement.*

Some Remarks on Proposition II

The current "constitution" is imperfect because of the incentive issue, not because of the inefficiency from risk sharing. First, the local government has little incentive to invest on the infrastructure in the rural area. The reason is simple: no matter what the production level is, the tax can be collected is fixed. Under the assumption that the probability of achieving higher production level is higher under higher effort of public goods provision, according to equation (9) and (10), a higher level provision of public goods surely means a Pareto improvement because the socially marginal benefit is

[51] This conclusion is consistent with the data.

greater than the socially marginal cost. Therefore we say that the outcome under the current situation is not socially efficient. This is consistent with the observed facts.

Second, what is surprising is that the allocation of risks is efficient. In this system the farmers take all risks, since the local government's tax collection at the amount of $t^{fixed} = v^{-1}(\overline{m} + c(a^l))$ is guaranteed no matter what the production level is. This surprising outcome results from the assumption that the local government is risk averse.

The central government stipulates the fixed tax in the constitution, in hope that local government can use the money collected in this way to finance the infrastructure in the rural areas. However, even if the local government has the incentive to invest on local infrastructures, the revenue from the constitutional tax imposes a further limit on the fulfillment of the task. The deficiency in revenue source of providing local public goods, and more importantly, of fulfilling other local expenditure objectives, promotes local governments to collect more than the stipulated fixed amount from farmers. In the past several years, the central government issued a lot of regulations to impose a ceiling on the revenue that local governments are allowed to collect from the farmers. One of the most important regulations is that the local government can only collect up to 5% of the farmer's total annual revenues. In the reality, the local governments circumvent the regulation by artificially exaggerating the farmers' income or the tax base and therefore collecting bigger amount. Or, alternatively, farmers are forced to conduct special agriculture activities such as growing special economic plants. These economic plants

may be important raw materials to the local enterprises, which is in turn important to the local tax base; or can bring about higher tax by themselves since taxes from these special products are proportional to the production. For example, every year the Xin County government in Henan Province stipulates the farmers in their jurisdiction plant Chinese chestnuts, which is an important economic crop contributing to local revenue.[52] Sometimes the farmers have to sacrifice the production of other more important agricultural products in order to meet the mandates from the county government. Then on the one hand, little incentive of providing public goods that are beneficial to agricultural production lowers the probability of obtaining higher production. On the other, many items of surcharges collected often by coercive power, in addition to the fixed tax, worsen the farmers' situation. If there is a good harvest, after submitting the taxes to the local government, the farmers might be able to maintain a fair life. If the production level is low, however, there will be a possibility of potential social instability.[53] To solve this problem we may need reforms in other sectors such as constructing more complete property rights, building up more efficient legal system, etc. However, before those can be done, in the following we are going to propose a solution by promoting local government's incentive of providing public infrastructures, and therefore improve farmer's welfare by at least make it more probable for farmers to obtain good harvest.

[52] This is from the author's personal experience in Henan Province.
[53] By this way, our approach provides a new explanation to the variance of the farmers' living standard. This is different from the view of "over exploitation" of the local government to the farmers' output (Tao et al. 2003).

A Solution to the Moral Hazard Problem

The disconnection between the tax revenue and agriculture production leads to the moral hazard problem. The solution to the problem lies in the incentive problem behind the local governments. The solution in turn points to the direction where the current tax reform should go.

Typically, to reach the solution we need to solve a two-stage model. First, we can characterize the local government's best response in stage two.[54] In this case, the central government cannot force the local government to participate; instead, the central has to offer the local at least the reservation revenue of what the current resource can bring about, $\overline{m}$. Therefore, the individual rationality constraint must hold. Also, if we assume equation (9) or (10) hold, then it is optimal for the central government to induce higher effort. In this context, the incentive compatibility constraint must hold; otherwise the local government will not exert a higher-level effort.

We turn next to the central government's revenue maximization problem at stage one. Since the center can solve the local government's second stage problem as well as the local government can, the central government should anticipate that the local government's reaction to the tax structure $t^i(x)$ would be to choose the effort level of investment $a^*(t^i(x))$, taking into consideration of $t^i(x)$. Specifically, we want to

[54] In theory, if the agent is risk-neutral, the principal can "sell" the land to the agent. However, even if the local government is risk-neutral here, the central cannot sell the land to the local. The reason is that, without requirement in other part of the "constitution," local government may not be interested in investing on agriculture sector.

construct the tax schedule in such a way that the local government will provide higher level of effort. Therefore, the central government's problem at the first stage amounts to

$$\max_{\{t^i(x^h),\, t^i(x^l)\},} w = p_1(x^h - t^i(x^h)) + (1 - p_1)(x^l - t^i(x^l))$$

Such that the following two constraints

$$p_1 v(t^i(x^h)) + (1 - p_1) v(t^i(x\ )) - c(a^h) \geq \overline{m} \qquad \text{(IR)}$$

$$p_1 v(t^i(x^h)) + (1 - p_1) v(t^i(x^l)) - c(a^h) \geq p_2 v(t^i(x^h)) + (1 - p_2) v(t^i(x^l)) - c(a^l)$$

(IC)

In our model, offering some incentives means that both the incentive compatibility constraint and individual rationality constraint should be binding. The reason is that, firstly, the local government is assumed to be risk averse. The central government can give local government some insurance by narrowing the difference between $t(x^h)$ and $t(x^l)$ in order to reduce the variance of the tax revenue, and making the incentive compatibility constraint hold at the same time. Second, the benefit that the central government offers to local government must be as high as the alternative return, $\overline{m}$. So we get the following two equations.[55]

$$p_1 v(t^i(x^h)) + (1 - p_1) v(t^i(x^l)) - c(a^h) = p_2 v(t^i(x^h)) + (1 - p_2) v(t^i(x^l)) - c(a^l) \qquad (16)$$

$$p_1 v(t^i(x^h)) + (1 - p_1) v(t^i(x^l)) - c(a^h) = \overline{m} \qquad (17)$$

The associated Kuhn-Tucker conditions are the usual ones. Also, both of the shadow prices are positive. Thus we have the following solutions.

[55] The superscript i here means "imperfect information."

$$t^i(x^h) = v^{-1}\left(\overline{m} + \frac{(1-p_2)c(a^h) - (1-p_1)c(a^l)}{p_1 - p_2}\right) \qquad (18)$$

$$t^i(x^l) = v^{-1}\left(\overline{m} + \frac{p_1 c(a^l) - p_2 c(a^h)}{p_1 - p_2}\right) \qquad (19)$$

The solution is essentially a compromise of incentives and risk sharing. Under this new tax structure, we will have the local government's utility is

$$u^{*i}(high) = p_1 v(t^i(x^h)) + (1-p_1)v(t^i(x^l) - c(a^h) = \overline{m}$$

And the farmer's profit is

$$w^{*i}(high) = p_1(x^h - t^i(x^h)) + (1-p_1)(x^l - t^i(x^l)) \qquad (20).$$

We will discuss the policy implications later in detail.

To summarize, we have the following proposition.

Proposition III: A contract described by (18) and (19) can solve the moral hazard problem in the current tax system. The optimal contact requires the risk-averse agent share some risks with the principal, so there is no full insurance offered to local government.

Some Remarks on Proposition III

Equation (18) and (19) design a new "constitution" $\{t^i(x^h), t^i(x^l)\}$with incomplete information. To understand the characteristics of the constitution $\{t^i(x^h), t^i(x^l)\}$, we need to compare it with the solutions under complete information and under the current tax structure.

About the production level

Let us consider the effects of the new "constitution" on the farmer's benefits.

Comparing equation (14) with equation (20), we can easily show that $w^{*i}(high) > w^{fixed}(low)$. Further, when comparing equation (6) and (20), we can find whether we have $w^{*i}(high) \geq w^{*}(high)$, or,

$$w^{*i}(high) - w^{*}(high) = (t(x^h) - t^i(x^l)) - p_1(t^i(x^h) - t^i(x^l)) \geq 0$$

It depends on the value of the difference between $t^i(x^h)$ and $t^i(x^l)$. This difference determines if the central government has incentive to carry out the new tax structure. Actually in this simple case, the difference will be zero, leaving the central indifferent to it. But the perfect information that we assumed in the benchmark case is idealistic. Under imperfect information, the new tax structure gives the central higher welfare compared with the fixed tax case, therefore is more favorable.

Two outcomes can be derived from the above analysis. Firstly, $w^{*i}(high) > w^{fixed}(low)$ shows that the new production level resulted from the higher effort induced by the new constitution is definitively higher than the production level under the fixed tax. By attaching the production level to the tax revenue, the local government would have incentives to invest on agriculture sector. The increased provision of public goods increases the probability of achieving higher production level. The new tax system will increase welfare in term of the efficiency in production.

Secondly, the allocation of the increased production between the farmer and the local government depends on some parameters. In our model, the utilities local government can obtain in both cases are the same whether the new tax structure is adopted or not. But a higher expected return is associated with the new tax structure

$\{t^i(x^h), t^i(x^l)\}$. The benefit of the local government can gain from the increased expected return is offset by the increased risks associated with the new constitution. The reason is that, for the risk-averse local government, some risk premiums are needed to compensate for the loss caused by exposing to risks. Apparently, here all the increased benefits go to the farmers. This is not the general case, however. A simple model like what we are using in this paper cannot determine the general allocation of increased benefit.[56]

About the risk sharing issue

This section is designed to compare the efficiency of risk allocation between the new "constitution" and those of benchmark and current tax system.

(i) New "constitution" v. s. the Benchmark

Different from the first-best case, in a second-best world, there is no full insurance available to the local government. In the benchmark model with perfect information, when the higher-level outcome is realized, the local government will get $t(x^h) = v^{-1}(\overline{m} + c(a^h))$. With imperfect information, when the higher-level outcome is achieved, the associated return is $t^i(x^h) = v^{-1}\left(\overline{m} + \frac{(1-p_2)c(a^h) - (1-p_1)c(a^l)}{p_1 - p_2}\right)$, which is bigger than $t(x^h) = v^{-1}(\overline{m} + c(a^h))$.[57] This positive difference means that the local

[56] To consider a model that involves benefit allocation, we can think of a model with a bonus. Bonus is widely used in firms that use high-power incentive programs. In the case with bonus, the bonus itself can be regarded as one form of redistribution of efficiency gain brought about by the incentive programs between the principal and the agent.
[57] Please refer to proof in appendix.

government can gain more with incomplete information than with complete information when the higher-level outcome is realized.

When the lower-level outcome is realized, we have different story, however. With complete information, the return associated with lower-output is $t(x^l) = v^{-1}(\overline{m} + c(a^l))$. Under incomplete information, when the lower-level outcome is realized, the return is $t^i(x^l) = v^{-1}\left(\overline{m} + \frac{p_1 c(a^l) - p_2 c(a^h)}{p_1 - p_2}\right)$, which is smaller than $t(x^l) = v^{-1}(\overline{m} + c(a^l))$.[58] Therefore, the local government would gain less with incomplete information than that with complete case when the lower-level outcome is achieved.

The effects of incentive highly depend on the values of $t^i(x^h)$ and $t^i(x^l)$, which determine how powerful the incentive is. We should, however, focus on the lower tax, $t^i(x^l)$. The reason is that the magnitude of $t^i(x^h)$, increasing the variance of the expected return in a good direction, therefore is good for the local government for it enables local government to obtain higher revenue. What really matters is the difference between $t(x^l)$ and $t^i(x^l)$, since a very low value of $t^i(x^l)$ will result in very low revenue proceeds for the local government by increasing the variance of the expected return in a bad direction. As the difference between $t(x^l)$ and $t^i(x^l)$ becomes bigger, the revenue of the local government becomes more unfavorable (Chavas 2004).[59]

[58] Please refer to proof in appendix.
[59] There is more detailed account on the upside and downside variation in chapter 6, Mean Variance Analysis, in the book cited above.

This difference can be expressed as

$t(x^l) - t^i(x^l) = v^{-1}(\overline{m} + c(a^l)) - v^{-1}\left(\overline{m} + \frac{p_1 c(a^l) - p_2 c(a^h)}{p_1 - p_2}\right)$. We already proved above that this expression is greater than zero. Comparing the arguments of the inverse function we can have that the difference is determined by the difference between $c(a^h)$ and $c(a^l)$. As the difference becomes bigger, the effects of the incentive become more powerful. In this case, compared with the first-best case, the expected tax in the second-best world is more risky.

Obviously, there is an efficiency loss caused by the new risk allocation. This risk allocation is not efficient because the two parties have different attitudes toward the risk. The efficient risk allocation requires that the risk-neutral central government take all risks and the risk-averse local government be risk free. To obtain a higher production level, we need to give local government incentives. The only way to do so, however, is to let the risk averse local governments share some risks.

(ii) New "constitution" v. s. the current tax system

Compared with the current fixed-tax system, the new "constitution" is again inefficient in term of risk sharing, since the risk-averse local government has to share some risks. However, the new "constitution" is socially efficient in terms of second-best.[60] This is because the efficiency loss in risk sharing will be compensated by the efficiency gains in production.

[60] The second-best means that the central government can not observe the behaviors of local government behaviors perfectly, different from the perfect information that we assumed in the benchmark case.

Therefore no matter compared with the benchmark case or the current system, the new "constitution" is inefficient in term of risk sharing. This efficiency loss, as we analyzed above, is actually the price in exchange for the efficiency gain in the production because the latter requires the local government take some risks. This trade-off is inherently rooted in the solution to the current Chinese tax system. What we need to do is optimally allocate the incentives and risk sharing to a point such that the gain from higher incentive equals to the loss from risk reallocation.

Implications for Tax Policy Design

After solving the moral hazard problem, the question becomes where we should go in reforming the Chinese current tax system. The following questions should be answered before reforming the system.

Question 1, should we give up the fixed head tax system?

The answer to this question is definitely yes. But before we can do it, we will have to find an alternative to replace the current tax.

Question 2, shall we change the uniform tax structure?

The uniform "constitution" across the whole country may not be efficient. From Proposition I, we can see that the optimal choice of t^* may be very different across the country because each individual locality has its own unique production function, based on which the actual choice is determined. In a greatly diversified country like China, the production function may not be uniform. As a result, the values of $c(a^h)$ and $c(a^l)$ can vary significantly across the whole country. The uniform tax totally neglects the

variations and thus is problematic. However, that would imply a very complex "constitution" or tax system.

Question 3, do we need an agriculture tax?

We will encounter a typical conflict between two principles of tax policy in discussing this problem. On one hand, a tax should be based on ability to pay. On the other hand, tax should be levied on those who can benefit from the services financed by the tax revenue. If the first principal is adopted, there should be no tax on the farmers at all, since the farmers in China are typically too poor to pay any taxes. If the second is adopted, the government should tax the farmers because the infrastructures in the rural areas in China can improve agriculture production and thus benefit the farmers.

If we consider efficiency only, this conflict can be solved such that the center takes all responsibilities to construct the dams and roads and other infrastructures to a point where the marginal benefits equalize the marginal costs, without agricultural tax collected from the farmers. This solution implicitly redistributes income from non-agriculture sectors to agriculture sector and is appealing at the first sight. In the real world, there have also been intensive discussions on the legitimacy of eliminating the head tax since last year. The prime minister, Wen Jiabao has announced the goal of abandoning the agriculture tax in the coming five years. And Hangzhou Prefecture government has already eliminated this tax. It apparently becomes an important element of the current tax reform and is launching. However, this option may not be a good solution, since it will lead to another type of moral hazard problem. The arrangement that

center takes all responsibility means that the infrastructures become free lunch for farmers. A higher demand than optimum on center's investment will not be a surprise. Also, without agriculture tax, the government will not have any incentive to invest in agriculture sector at all!

In addition to the lack of appeal on the economic ground, this solution, however, may be very difficult to implement because of the characteristics of the current political regime and long-standing ideology of giving priority to industry instead of agriculture, even though it is long been advocated that more weight should be allocated to the latter, as we mentioned in the part above.

We may still need an agriculture tax, but not the head tax that we currently have. If we can design a tax relating the agriculture production with agriculture tax, as advocated by the imperfect information case discussed in our model, then we might be able to not only provide local government incentives to invest on infrastructures, but also guarantee tax revenues to fulfill the task.

Conclusion

It is not very easy to understand the behaviors of Chinese local government within the traditional framework. In this paper, the behaviors of Chinese local governments have been examined in a unique angle, by expanding B-B rule to include the risk issue. A simple moral hazard model in a principal-agent framework has been constructed to illustrate the problems inherent in the current agriculture tax system in China and ways of solving the problems have been proposed. Our propositions may throw new lights on the behaviors of Leviathan-like governments. Of course, here we did

not consider the transfers from the central government to local governments, thus such situations as when the local governments collude with the farmers, in order to obtain more transfers from the center; or when the local governments are simply corruptive in delivering public goods and drive up the costs, the cases that will complicate the issue are not included. We consider those possibilities for future developments.

Appendix

Proof of Footnote 57:

$$t^i(x^h) = v^{-1}\left(\overline{m} + \frac{(1-p_2)c(a^h) - (1-p_1)c(a^l)}{p_1 - p_2}\right) > t^h = v^{-1}(\overline{m} + c(a^h))$$

Since the two taxes, the tax under higher production level in incomplete information case, $t^i(x^h)$, and the tax under higher production level in the benchmark case, t^h are both denoted in the inverted function form, we can prove this inequality by comparing the arguments.

Then our problem becomes the following:

$$\begin{aligned}
&\overline{m} + \frac{(1-p_2)c(a^h) - (1-p_1)c(a^l)}{p_1 - p_2} - (\overline{m} + c(a^h)) \\
&= \frac{(1-p_2)c(a^h) - (1-p_1)c(a^l)}{p_1 - p_2} - c(a^h) \\
&= \frac{(1-p_2)c(a^h) - (1-p_1)c(a^l)}{p_1 - p_2} - \frac{(p_1 - p_2)c(a^h)}{p_1 - p_2} \\
&= \frac{(1-p_2)c(a^h) - (1-p_1)c(a^l) - p_1c(a^h) + p_2c(a^h)}{p_1 - p_2} \\
&= \frac{c(a^h) - (1-p_1)c(a^l) - p_1c(a^h)}{p_1 - p_2} \\
&= \frac{(1-p_1)c(a^h) - (1-p_1)c(a^l)}{p_1 - p_2} \\
&= \frac{(1-p_1)(c(a^h) - c(a^l))}{p_1 - p_2}
\end{aligned}$$

According to our assumption, $p_1 - p_2 > 0$; also we have $(1-p_1) > 0$ and $c(a^h) - c(a^l) > 0$. Therefore, both the nominator and the denominator are greater than zero, and the whole term is greater than zero. Then we have

$$\overline{m} + \frac{(1-p_2)c(a^h) - (1-p_1)c(a^l)}{p_1 - p_2} - (\overline{m} + c(a^h)) > 0$$

We assumed earlier that $v(\bullet)$ is strictly increasing in t, thus we will have that the $v^{-1}(\bullet)$ is also strictly increasing. Therefore, we have

$$v^{-1}\left(\overline{m} + \frac{(1-p_2)c(a^h) - (1-p_1)c(a^l)}{p_1 - p_2}\right) > v^{-1}(\overline{m} + c(a^h))$$

Or $t^i(x^h) > t^h$.

Proof of Footnote 58:

$$t^i(x^l) = v^{-1}\left(\overline{m} + \frac{p_1 c(a^l) - p_2 c(a^h)}{p_1 - p_2}\right) < t^l = v^{-1}(\overline{m} + c(a^l))$$

Since the two taxes, the tax under lower production level in incomplete information case, $t^i(x^l)$, and the tax under higher production level in the benchmark case, t^l are both denoted in the inverted function form, we can prove this inequality by comparing the respective arguments.

Then our problem becomes the following:

$$\begin{aligned}
&\overline{m} + \frac{p_1 c(a^l) - p_2 c(a^h)}{p_1 - p_2} - (\overline{m} + c(a^l)) \\
&= \frac{p_1 c(a^l) - p_2 c(a^h)}{p_1 - p_2} - c(a^l) \\
&= \frac{p_1 c(a^l) - p_2 c(a^h)}{p_1 - p_2} - \frac{(p_1 - p_2) c(a^l)}{p_1 - p_2} \\
&= \frac{p_1 c(a^l) - p_2 c(a^h) - p_1 c(a^l) + p_2 c(a^l)}{p_1 - p_2} \\
&= \frac{-p_2 c(a^h) + p_2 c(a^l)}{p_1 - p_2} \\
&= \frac{p_2 (c(a^l) - c(a^h))}{p_1 - p_2}
\end{aligned}$$

We assumed in the essay that $p_1 - p_2 > 0$, also we have that $c(a^l) - c(a^h) < 0$. Therefore we have that

$$\overline{m} + \frac{p_1 c(a^l) - p_2 c(a^h)}{p_1 - p_2} - (\overline{m} + c(a^l)) < 0$$

Since we assumed earlier that $v(\bullet)$ is strictly increasing in t, thus we will have that $v^{-1}(\bullet)$ is strictly increasing. Therefore, we have

$$v^{-1}\left(\overline{m} + \frac{p_1 c(a^l) - p_2 c(a^h)}{p_1 - p_2}\right) < v^{-1}(\overline{m} + c(a^l))$$

Or $t^i(x^l) < t^l$.

CHAPTER III

ESSAY II BUDGET STRUCTURE AND ENVIRONMENTAL PERFORMANCE

Introduction

The theoretical model we dealt with in the first essay established the foundation of this current work. We have established that in theory, government does exhibit strategic behaviors, which results in different consequences. However, does the picture really look like this when we turn to the reality? Can we provide some evidence of our own to supplement the work already done? It is currently not possible to test the validity of the model we developed in the context of China, due to the data availability. Thus we turn to a broader viewpoint and try to find evidence from countries all over the world to test the theory developed in the first essay.

A fact we observe is that as economic growth and human activities increasingly have a negative impact on the natural environment, with more and more serious consequences start to produce negative feedback to human lives.

Environmental quality control has gained an increasingly important role in government policy and businesses practices as people become more aware of the consequences of a polluted environment.

Nonetheless, there is a big gap in the level of economic growth and development across countries and the same is true for the environmental quality across countries. This

difference in environmental quality can be attributed to the variations in economic conditions, natural endowments, social factors as well as government policies.

The specific question we are interested in is: do differences in government budget structure give government agencies different incentives to engage in environmental quality control?

Before the 1990s, differences in economic growth across countries were cited as the standard explanation for the observed variation in environmental quality. Pollution was interpreted as an unavoidable by-product of industrialization, and therefore it was seen as an increasing function of economic growth. Following this point of view, developed economies have seen their environments damaged at a faster pace than developing economies (Meadows et al. 1972).

However, beginning in the early 1990s, a number of empirical studies showed that the relationship between pollution and economic growth was not as simple as it was thought before. 61 Pollution was found not to be a monotone function, but rather a concave function of GDP. This result became known in the literature as the Environmental Kuznets Curve (EKC), borrowed from the classic Kuznets Curve, which relates the distribution of income to the level of income. EKC states that in the early stage of economic growth, pollution increases. Once GDP per capita achieves certain level, the relationship reverses. In other words, economic growth contributes to the

[61] These empirical works are mostly on the Environmental Kuznets Curve (EKC), a literature that we review later in this essay.

reduction of pollution once it achieves a certain level. The reason is that economic growth creates demand for higher environment quality; the better definition of property rights and other institutional arrangements make it possible to reduce pollution and improve environmental quality.

The EKC hypothesis explains the variations in environmental quality mostly through the variations in GDP per capita. [62] But a lot of other factors are surely missing from this framework. In particular, from our point of view, the fact that environmental quality is a public good should be recognized; therefore government behavior must be taken into consideration explicitly when we try to understand environmental variations.

Environmental quality can affect government behaviors through two different channels. On the revenue side, pollution is positively related to production levels, which in turn represent the tax base of major taxes, such as the VAT and other business related taxes. Since higher production means higher tax revenues, government may tolerate higher levels of pollution for the purpose of obtaining higher income, thus resulting in a relatively low effort of pollution control. This can be measured by the importance of VAT and other business related taxes in total tax revenue.

On the other hand, pollution can damage other tax bases. This is especially true in the case of the property taxes. The extent of this damage may also affect government's

[62] In our opinion, "environmental behavior" is a more precise term than "environmental quality". Environmental quality is actually the consequence of the agent's environmental behaviors. For example, some communities pollute more than others; while they spend more money in dealing with pollution problems at the same time. However, some communities do not take responsibilities for the consequences caused by their behaviors. However, in order to be consistent with previous studies, we are following the traditional use of the term, environmental quality.

incentives on the revenue side of the budget to control pollution. This can be captured by the share of property tax in total tax revenue.

On the expenditure side of the budget, more pollution means more expenditure on healthcare, due to the negative effects most pollutants have on human health, thus pollution levels may significantly affect the composition of government budgetary expenditure. But the government's incentives to control pollution may vary depending on how costly pollution may be to the budget. This latter maybe roughly approximated by the ratios of government expenditure on health care over total public expenditure. There is some obvious endogeneity issue here: the level of pollution affects health care expenditures, but the composition of the budget, which also reflects how much we care about pollution, may also affect the level of pollution, or at least anti-pollution policy efforts. This will be a problem we have to deal with in our estimation.

In addition, the political characteristics of different countries might have an impact on the policy making process for different governments, including the environmental policy. For example, democratic countries and non-democratic countries might care about the environmental quality to a different extent, since in the former, voting system works well and the preferences and interests of the residents are more fully respected; while in the latter case, the authoritarian way of decision making does not necessarily take into account the needs of the residents. Thus the country's political regime might play a role in maintaining environmental quality.

This essay is intended to capture the relationship between budget structure and government's incentive of pollution control, with the hope of offering a new angle in tackling the environment problems.

This essay is organized as follows: in the next section, we review the EKC hypothesis, which we take to be the prevailing explanation on the relationship between economic growth and environment quality, and point out the main weaknesses of this hypothesis. In Section III, we offer a new explanation, which takes into account government incentives for controlling pollution level under different budget structures. In section IV, we develop a theoretical model, based on the Leviathan government's revenue maximization hypothesis, formalizing the relationship between budget structure and pollution control. Then we offer three propositions following the implications derived from our theoretical model, which may have important policy relevance for environment policy. The first hypothesis states that the higher the ratio of business related taxes as proxied by general value added, sales, or turnover taxes collections in total revenue, the lower incentive of the government to control pollution and thus the higher the pollution level. The second states that higher percentage of property tax in total tax revenue will give governments an incentive to lower pollution level.[63] The third one says the higher the share of government health care expenditure in total public expenditure, the lower the pollution level.[64] In Sections V and VI, we test the three hypotheses, using a

[63] This is based on the assumption that most of the pollution has an impact on urban areas where housing is concentrated, a point that we will come back to later.
[64] Of course, the endogeneity issue should be taken care of first.

cross-section, time series data set including 108 countries over the time period of 1990-2002. Our results suggest that, changes in budget structure may have an important impact on government behaviors and therefore on the environmental performance. Therefore, government incentives to fight pollution should be taken into account when making environmental policy decisions.

The Conventional Hypothesis on Economic Growth and Environment Quality (EKC)

Before the 1980s, economists traditionally thought that more developed economies were damaging their environments at a faster pace (Meadows et al. 1972); the conventional wisdom was that environmental quality gets worse as the economy grows. However, the changes in demand for environmental quality and the actual level of it were not consistent with this traditional view. In the 1980s, the empirical evidence showed that people in advanced economies had a very strong demand for environmental quality. The reason appears to be quite simple: environmental quality is a normal good; therefore as people become richer, through conventional income effects, people demand more of it. Therefore, as economies grow, environmental quality actually improves rather than deteriorates.

Motivated by this new evidence, economists in the early 1990s began to challenge the old view. They found some empirical evidence to show that the relationship between economic growth and environment quality was non-linear (Grossman and Krueger 1994; Panayotou 1995; 1992). In fact, environmental quality was found to be a concave function of economic growth. At the early stages of economic growth, when the

activities are small in scale, the economy does not produce much pollution. As the economy grows and production begins to expand, the benefits from production increase, but so do the pollution levels. At some point, pollution levels reach their peak. Beyond this point, the demand for environment quality increases because the disutility from higher pollution now outweighs the "benefit" from pollution (in terms of higher pollution being the by-product of higher production and incomes), and people now are not only willing to, but also are capable of controlling pollution due to the growing income level and technology available; therefore at some stage of economic growth, the pollution level begins to fall. [65] EKC is essentially a hypothesized relationship between levels of various indicators of environmental performance and GDP per capita, with the relationship depicted as taking an inverted-U shape.

The EKC has important policy implications. It predicts that economic growth itself will be sufficient to improve the environmental quality. If the EKC hypothesis holds, we can draw the conclusions that once economic growth reaches certain level, it will have a positive effect on environmental quality. Therefore, there is no need to worry too much about pollution problems.

Some Empirical Evidence

Fundamentally, the EKC is an empirical phenomenon. Among other studies, Shafik and Bandyopadhyay (1992), Panayotou (1993; 1995), Grossman and Krueger

[65] All EKC literature traditionally investigates the relationship of economic growth and environmental indicators, and the level of economic growth usually measured by GDP per capita. In this essay we follow this tradition.

(1994), Selden and Song (1994) are widely recognized as the earliest EKC contributors (Yandle 2002). Grossman and Krueger (1994) tried to verify the existence of EKCs using data for SO2, dark matter, and SPM (Suspended particulate matter) from GEMS (Global Environmental Monitoring System), published by the World Health Organization. These data measured ambient air quality in two or three locations in each city within a number of countries during the period 1977-1988. Their regressions included location, time and also a trade intensity variable. In their results, SO2 and dark matter conform to the EKC hypothesis, first increasing with income, then starting to decrease after some level of income; while the level of SPM exhibits a monotone declining trend even at the low-income level, without reaching some turning point. Selden and Song (1994) estimated the EKCs for SO2, NOx, SPM and CO using a cross-section and time-series data set from World Resources, taking into consideration of country specific effects and time specific effects, as well as population density. They obtained results favorable to EKCs except for CO. In his influential paper, Panayotou (1993; 1995) estimated EKCs for SO2, NOx, SPM and deforestation using a cross-section data set. His conclusions provide support to EKC hypothesis in that the estimated curves for SO2, NOx and SPM do exhibit an inverted-U shape with respect to income per capita. For example, his regression outcome on SO2 takes the form $\ln(SO2/P) = -35.26 + 8.3\ln(Y/P) - 0.51\{\ln(Y/P)\}^2$, clearly exhibiting an inverted-U shape.

A lot of studies have estimated the turning points of income, i.e., at what level of income the environmental quality starts to improve. Usually for different pollutants, studies found that the turning points are different. For example, Grossman and Krueger (1994) found that for SO2 and dark matter, the turning points could be achieved when per capita GDP is around $4000-5000 in 1985 U.S. dollars. In Panayotou (1993)'s work, if measured in 1985 U. S. dollars, he obtained the turning points for SO2 at per capita GDP of around $3000, around $5,500 for NOx, and around $4,500 for SPM. [66] In terms of the regression function above, it means the level of SO2 pollution decreases at per capita GDP of around $3000.

Some Problems with the EKC

Since its birth, the EKC evidence has been in the center of debate. In general, there is consensus in the literature that the EKCs suffer from some problems. A first problem concerns the data that researchers have been using. Most of the EKC literature uses data aggregated over different units, which imposes a potential heteroskedasticity problem (Stern 2003; Stern 1996). In addition, the environmental data available to researchers are not necessarily reliable since the environment is notorious for its volatility and makes it extremely difficult to obtain environment related data, let alone reliable data. A second problem is that, as Arrow et al (1995) pointed out, the EKCs only consider the impact of production on the pollution of the environment, assuming that there are no feedback effects from the environment to the production process. This

[66] In Yandle (2002), there is a good summary of turning points in different EKC literature.

assumption seems impractical in view of the ever-increasing economic activities worldwide and the limited carrying capacity of the environment. When, for example, the rate at which the production process consuming underground water resources exceeds the capability of the natural water system to make up the loss, the environment might impose adverse effects to the production process, either take the forms of deterioration of water quality or land collapse. A third problem is that the EKC literature does not take into consideration of other factors such as environmental regulation, relative advantages in international trade, etc. Strict environmental regulation in developed countries may prompt manufacturers to move their heavy-polluting industries to developing countries (Stern 2003).[67] Developed countries are more and more concentrating on capital and human capital-intensive service sectors, which is helpful for the improvement of environmental quality (Hettige, Lucas, and Wheeler 1992).

More fundamentally, even if the relationship between environmental indicators and GDP per capita does exist, what is the reason behind that? The EKCs believe that as income increases and people demand higher environmental quality, environmental quality will be improved by market power, instead of the effects of government intervention. Thus, it leaves no room or at least it does not require the role of government. However, in the real world, government is the provider of most public goods, including environmental quality control. As any other public good, the extent of environmental

[67] This is the “race to the bottom” that we are going to dwell upon later.

quality control is very likely to be determined through a public choice process. [68] In addition, the EKC hypothesis allows no role for the institutional differences between governments, for example, with or without democratic voting systems, of course the environmental outcomes will be affected significantly.

Being aware of these points certainly raises several important questions. For example, even in countries in which there are effective democratic voting systems, the residents may not be able to control government behaviors simply by elections.[69] Then, in countries without voting system, what factors influence the decisions making of the government? Therefore, in order to have a better understanding of environmental performance in different countries, we need to examine the role of government, analyzing how government behavior can affect environmental quality, both directly and indirectly.

Budget Structure, Government Behavior and Pollution Control

By most standards, environmental quality is a public good, even though some part of it is a local public good, and another part is a "global" public good. The reasons are obvious. Environmental quality shares two properties with other public goods, such as national defense and street lights: being non-rival and non-excludable.[70] The environmental quality we are talking about here includes the quality of clean water, clear

[68] For example, the demand for a particular level of environmental quality can be regarded as a choice of the median voter, according to median voter model (MVM). However, there will be some other problems if we apply the MVM here, mainly due to the problems inherent in the MVM, such as the preference needs to be single peaked, and so on.
[69] See for example the discussion of the original work on Leviathan model, in Buchanan and Brennan (1977; 1978; 1980). See also Niskanen (1968; 1971)for the original bureaucratic model of decision making in government.
[70] However, we could define the abuse of the environment (e.g. the atmosphere) by one country reduces the level of the good available elsewhere. For example, acid rain is such a case.

air and so on. There may be some rivalry: if one person uses the clean water or clear air, there might be less of it available to others. Use of water may also be excludable since people who do not have access to water can be excluded from its use. In this sense, these goods are not strictly pure public goods. Nonetheless, water and air are both renewable resources, especially under current technologies; thus, we can call them public goods without violating the general definition of a public good.

In general, public goods are provided by the government and financed by taxes or user fees. The residents consume the public goods and at the same time pay tax to finance the provision of these goods.

As mentioned above, the EKC hypothesis assumes no role for government. This assumption, however, does not appear to be very reasonable since governments across the world are influential in almost every aspect of the economy.

In general, from the perspective of this essay, governments can be grouped into two types, democratic and non-democratic. Democratic countries use voting and other procedures to form the social preference over public goods, while in non-democratic countries voting does not exist or does not work, and collective decisions are made in some authoritarian manner. Even within the same type, the level of government that is responsible for environmental quality control may be very different. In some democratic regimes, it is central government's responsibility to regulate environmental problems, in order to enjoy the benefits of economies of scales, and avoid the potential side effects, such as spillovers of pollution. Under this circumstance, it is still possible that local

governments have an important impact on pollution. For example, in the US where environmental problems are largely the responsibility of the federal government, New York City and eight state governments have planned to sue power plants. [71] The reason is that the emissions of the power plants, as they put it, "pose serious threats to our health, our economy and our environment." In some other democratic countries, however, the authority to regulate environment is assigned to government agencies at the state (regional) or local levels in order to accommodate for the diversities in preferences and needs in different localities. This can create problems of its own, but we will not expand this line of research in here.[72]

No matter which level of government is responsible for the environmental quality control, the government's incentives to achieve the goals of environmental improvement, in addition to the capability of doing so, are important issues that need special attention. There are relatively few papers in the literatures that have explored the role of environmental governance. The work by Dasgupta et al. (2004) is unique from this perspective. Their results show that governance does play an important role in controlling environmental quality. Without strong environmental governance, rich countries whose incomes already reached the turning point predicted by the EKC hypothesis would not necessarily accomplish the actual decrease of pollution levels.

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[71] The states include California, Connecticut, Iowa, New Jersey, New York, Rhode Island, Vermont and Wisconsin, from the New York Times, July 21, 2004.

[72] For example, Oates (2001) differentiated between three different cases in which he treats environment quality as pure public goods, local public goods, or the pollution can flow across boundaries and results in spillovers. Depending on different situations, different level of governments or the coordination by different level of governments should be responsible for the formation and implementation of environmental policies.

Similarly, we will expect that “low levels of development do not prevent countries from having effective environmental institutions and policies” (Dasgupta et al. 2004). Therefore, poor countries can achieve high level of environmental quality if strong environmental governance is in place. Thus, Dasgupta et al. (2004) observe that the EKC framework is misleading since it suggests only when income achieves certain level can the level of pollution possibly starts to fall. In their view, the policy of “grow first, then clean up” is invalid. [73]

In the public finance literature, as mentioned in the first essay, there are three main models about government behaviors. The first one is median voter model (MVM). The MVM is the most popularly used tool in the field to analyze the outcome of public choice within a democratic context. A voting system is used to form the public preference for public goods under a democratic regime. The median voter is defined as the voter whose preferences lie in the middle of the set of all voters’ preferences (Rosen 1999). The MVM hypothesizes that as long as all preferences are single peaked; the outcome of majority voting reflects the preferences of the median voter.

When we apply MVM to test empirically the demand for public goods, for example, we need to make an inherent assumption that each jurisdiction’s (county, state, or country) preference is represented by the preference of the median voter in the jurisdiction. As mentioned earlier, in order to analyze the relationship between

[73] They also look at the effects of geographic vulnerability to environmental damage and the sectoral composition of economic activity.

environmental quality and GDP per capita within the MVM framework, we need more assumptions such as that GDP per capita can be used as a proxy to the median voter's income; that the preference of residents should be normally distributed and single peaked.

Even if it is justifiable to interpret EKCs as the outcome of median voter's choice, the MVM has some serious weakness itself. Theoretical arguments and empirical evidence show that the citizens cannot perfectly control government behaviors through the voting system (Matsusaka 1995; McGuire 1999). In addition, not all countries are democratic and have effective voting system. Just as we mentioned above, there are non-democratic countries, where no voting system exists, neither does MVM work. What is more, MVM is usually used to explain different social choices across localities within a country, while environmental policy is often the central government's policy target, even though sometimes being left within local governments' discretion; thus MVM might have difficulties in explaining the cross-country variations of environmental policies. Due to these reasons, we think that MVM is not an appropriate vehicle to explain the variations in environment performance across countries.

Alternatively, there are other two competing hypotheses about government behaviors: the Leviathan model and the bureaucratic model, which we mentioned in the first essay. The Leviathan model holds that the government can be modeled as an organization with its own interests. Without effective control from the citizens, the government may be willing to exploit its constituencies fiscally, trying to maximize its

potential revenue sources, or using minimum resources to meet some requirements, thus becoming a revenue-maximizing Leviathan (Brennan and Buchanan 1977, 1978, 1980). This Leviathan has an inherent tendency to maximize budgetary revenue; therefore the size of the government tends to be bigger than optimal. In the literature, the Leviathan model holds that the more decentralized the government structure, the tax competition among decentralized governments will put more restrictions on the government's intrusion into the economy, therefore, the smaller the size of the government. Researchers have controversy over the evidence on the relationship between decentralization and government size, however. For example, Oates (1985) found no relationship between decentralization and government size, while Stein (1999) found that fiscal decentralization led to larger governments in Latin America; and Marlow (1988), Grossman (1989) found negative relationship between decentralization and government spending.

According to the so-called bureaucratic model developed mainly by Niskanen (1968; 1971), bureaus are monopoly suppliers of the services they provide, with political sponsors as their monopoly buyers. Bureaus exchange a specific output by bargaining with the political sponsors for a specific budget. Also the bureaus have information advantages over the production costs, while the sponsors have neither the incentives nor the capabilities to monitor the behaviors of the bureaus due to symmetric information. In addition, Bureaucrats have their own utility functions, including "salary, perquisites of the office, public reputation, power, patronage, ease of managing the bureau, and ease of

making changes" (Niskanen 1975). Therefore bureaucrats will try to maximize their own interests, instead of maximizing social welfare (Niskanen 1971). In term of budgetary behavior, bureaucrats will try to maximize the size of the their discretionary budget, in order to get more out of it, of course subject to the cost constraint of producing certain output (Niskanen 1975; 1994). Niskanen also provided some empirical evidence on the overspending of the bureaus (Niskanen 1975).

Neither of these two models believes that voting systems can control government behaviors; instead, they argue that the residents cannot monitor the governments (or the government can not monitor the bureaucrats in the latter case) very effectively. This is so because residents may not have information on which politician can better accommodate their preferences. Or, citizens may not have enough incentives to vote because it is difficult or even impossible for one single vote to change the outcome of the election. Both models state that governments or bureaucrats try to maximize their own benefits, defined as the "surplus" of the budget.[74]

In our opinion, these two models have important implications for environmental performance, since the impacts of environmental performance on different budget structures give a Leviathan government or a bureaucratic official different incentive to control pollution.

[74] Both of these two models describe that the Leviathan government or the bureaucrats try to maximize the budget, then after fulfilling the expenditure responsibilities mandated by the constitution, the rest will be surplus of budget, from which the leviathan government or the bureaucrats can have more resource at discretion or simply derive more personal benefits.

Pollution, or poor environmental performance, has an impact on the Leviathan government or the bureaucratic official from both the revenue side and the expenditure side. On the revenue side, pollution could be both good and bad. Pollution is related inherently to production in that, in general, higher level of production brings about higher level of pollution. On the one hand, higher production can bring government higher value-added tax or other tax revenues collected from expanded production activities and enlarged economic base. On the other hand, however, higher levels of pollution that come along with the higher level of production may in turn damage base of some other taxes, in particular the property tax base.

As a rational agent, the government or bureaucrats would try to seek a balance between those two in order to maximize their revenue target. Under this situation, the tax structure may have a significant impact on the government's incentives to deal with pollution. If tax revenues are mostly taken up by business activity taxes, such as VAT, as opposed to residential bases, such as the property tax, then government will have incentive to expand economic activities, with the hope of compensating for the loss from property tax with more revenue from VATs. The government may not have much interest in controlling pollution in this case, since maximizing production means maximizing revenue. Controlling for pollution levels requires reducing production activities, and reducing tax revenue accordingly, therefore it could be irrational to make this decision for the sake of the tax revenue. However, if most tax revenues are from property taxes, in order to protect property tax base, government will have stronger incentive to control

pollution and impose more strict environmental regulations to protect the environment, lowering pollution levels as much as possible. Even though pollution is detrimental to the atmosphere in remote areas, too, it will not have a direct impact on property tax. Therefore, as we mentioned earlier, here we need to assume that we are focusing on the pollution that negatively affects values of property in urban areas.

It is interesting to note that in normative systems of revenue assignments at different levels of government, broad-based taxes, such as VAT and corporate income tax are assigned at the central government level, while property taxes are a much more ideal tax for local government (McLure 1983; Oates 1999) . These normative considerations are very often followed in actual assignments. All other things equal, we would have, therefore, that revenue maximizing local governments have much stronger interests in pollution control than central government in countries following this way of tax assignment. Consequently, we should expect in countries where property taxes have been assigned as an important source of local revenue, the higher proportion the property tax revenue takes up in local revenue, the more active environmental policies local government will have incentive to implement at the local level. Or the local government will impose pressure on the central government, if environmental policy decisions are made by the latter. The proportion of property tax in total tax revenue for upper level government, including states and federal government as in the US, will usually have no such effects, or not evidently so clear. This is partly due to the fact that for upper level

governments, the tax bases are more diversified, and property tax is usually not as a significant revenue source as at local level.[75]

On the expenditure side, if healthcare were constitutionally assigned to the government, the government or bureaucrats should have an incentive to curb pollution. The reason is that many pollutants may negatively affect the human beings' health status, which may in turn increase the government expenditure on health care. If the share of health care expenditure in total government expenditure is very high, in order to maximize the "surplus," less pollution would be preferred. If the share is very small, the government or bureaucratic officials may not care about pollution that much. Different from the case of considering property tax at central level and local level on the revenue side, we do not differentiate between health expenditure at the central and local levels. One of the reasons is that the data differentiated between local health expenditure and central health expenditure is not generally available. In addition, the effect of pollution on expenditure side should work for both the central government and the local government, since neither of them will be oblivious to the pollution problem if health expenditure takes up big shares in their budgetary expenditure. Therefore, in our analysis we use health expenditure in total public expenditure in a general sense.

In the following section, we will develop a theoretical model, starting from the revenue maximizing behaviors of a Leviathan government, formalizing the relationship between budget structure and the government efforts of pollution control.

[75] Besides, the negative consequence of pollution to the property tax base is more conspicuous at local level.

The model

Before the formal construction of the model, it is necessary to make some assumptions.

The economy

First we assume that the economy consists of only three key sectors and a Leviathan-like government. The government collects taxes and provides public goods. The residents cannot control the government behavior by voting system, either because there exists an asymmetric information problem related to voting (*Turnbull* and *Mitias* 1999), or simply because there is no voting mechanism in some countries, or because the voting system does not work. Instead, we assume the government is bounded by a "constitution," or the predetermined budget structure as described in essay one.

The first sector is manufacturing, which includes industries such as automobile, chemical, clothing and many more others. This sector is assumed to be a pollution-maker, with higher production bringing about more pollution. The second is real estate sector that consists of properties that can be used commercially or residentially. The third is the health care sector.

The last two sectors are assumed to produce no pollution at all. They are, rather, influenced negatively by pollution. For the real estate sector, pollution may drive down the market values for houses and land. For example, pollution may destroy some historical sites, and then significantly shock the local tourism sector. Also, pollution may make the environment in some community very unpleasant and lower the value of

property through capitalization. Pollution also has a negative impact on people's health conditions, and thus imposes heavy burden on health care industry. For example, the increases in the pollution level will increase the probability of people getting sick, as a consequence the health care industry will have to spend more. This is well established in the literature.[76]

The "Constitution" (the Budget Structure)

Tax revenue

In the economy the goal of the Leviathan-like government is to fiscally exploit the citizens, under the only constraint of the given constitution. On the revenue side, the government is granted the power to levy two kinds of taxes by the constitution, a business type tax such as VAT and a property tax. In addition, the tax rates are pre-determined by the constitution because the voters know well that otherwise the government would have an incentive to increase the tax rates at after-constitution stage in order to obtain more tax revenue, as we argued in the first essay.

Expenditure

On the expenditure side, the voters also know that the government wants to make the fiscal surplus as big as possible. Therefore it is rational for the government to spend as little funds as possible in order to obtain more surpluses, if there are no constraints. To deal with this problem, the constitution sets up some mandates on what the government

[76] For example, there is a causal relationship between pollution level and mortality rate (Dockery et al. 1993).

should provide to the residents. We assume that the government is obligated to provide public health services.

Thus the Leviathan government is required to provide two categories of public goods. One is related to the health care provision. Expenditure on education, infrastructure investment, social security and so on goes to the category of OTHERS, denoted by G. The reason we divide the expenditure responsibilities in this way is based on our assumption that the former category is influenced by pollution, while the latter is not directly related to pollution.

Economic policy

As a government, we assume that the only economic policy instrument at the Leviathan government's discretion is environmental policy. The government can use this instrument to serve its goal. In other words, the policy is a tool to balance the gain and loss at the revenue and expenditure sides of the budget, respectively.

The Model Specification

To capture the exact impact of pollution on the Leviathan government's behavior, and how the pollution level is determined, we need to specify the following variables.

We first assume that the government can perfectly control the pollution level. So the real pollution level d can be represented by the government efforts of controlling pollution, e. This implies that the environmental policy can achieve the desirable level of pollution, therefore the government can control the pollution to an extent that is optimal to the government. For the relationship between real pollution level d and the

government efforts of controlling pollution e, we have $d = d(e)$, and $d'(e) < 0$. Due to this, we can use *e* instead of *d* to explain the relationship between pollution and other variables. In other EKC literature, since the role of government is not a variable of interest, usually the pollution level itself is used.[77]

On the revenue side, the government has two sources of revenue. The first one is business tax. Given the tax rate τ_v, the only avenue for obtaining higher tax revenue is to expand the manufacturing production as high as possible since production level is the tax base of business tax. To increase its fiscal surplus, the Leviathan needs to seek the expansion of the production activities as far as possible. Production in this economy is inherently related to the level of pollution. As pointed out earlier, there is a positive relationship between production level and pollution level. The expansion of the production level will inevitably expand the pollution level. We assume that the production level is a function of pollution level d and the government efforts to control pollution: $f = f(d(e))$ and $f_e'(d) > 0$. and $f'(e) = \frac{\partial f}{\partial d} \bullet \frac{\partial d}{\partial e} < 0$. Hereafter, we will ignore the real pollution level d, and focus on government efforts of pollution control, e.

Because the base of the business tax is the production level, it relates to pollution level and therefore indirectly relates to the government effort to control pollution. We therefore define the base of business tax as $V = V(f(e))$, or simply $V = V(e)$. If

[77] In our estimation, we actually use the pollution levels instead, while controlling for the measure of governance, mainly due to the difficulty of quantitatively measuring the effort of government pollution control.

government applies higher environment standards and enforce the law more vigorously, the production level would be lower because the government's efforts of controlling pollution can significantly increase the prices of the inputs, driving up the costs of the production and reduce the profits. In some extreme case, the stringent pollution control may even make production unprofitable and therefore force the exit of some firms. On the other hand, if lower the environmental standards, the costs of locally produced products will be reduced; therefore expanding production will be more profitable. Also, more firms will enter the industry to take the advantages of these more polluter-friendly environmental standards (Smarzynska and Wei 2001). Under both of these situations the production would expand. Therefore there exists a negative relationship between production level and government efforts of curbing pollution, or $V_e^{'}(e) < 0$ and $V_e^{''}(e) < 0$.

In addition, the production activity plays different levels of importance at different stages of economic development (Balsdon 2003; Gallapher 2004). When GDP per capita is low, the economy may not have strong production capacities. As the economy grows, the manufacturing activities expand too. This positive relationship, however, does not last forever. At some points, this positive relationship may become negative in that developed countries may specialize on technology-intensive and human capital-intensive industries that are less pollution-conducive (Hettige, Lucas, and Wheeler 1992).[78]

[78] As countries become more developed, they tend to adopt human capital intensive technologies and provide more services instead of simply manufacturing products, different from mining and chemistry industries that are prevail in countries with lower level of development. Here we refer to those high-tech industries that require highly intensive technology and human capital and don't remit as much pollution as those relatively more primitive manufacturing industries.

One important phenomenon that needs to be pointed out is that, some developing countries take great efforts to attract more FDI inflows, which allows developed countries to relocate their heavy polluting industries to these developing countries, in order to take advantage of the lower environmental standards of the destination countries. This is the so called the “pollution heaven.” And even worse, if other countries get threatened by the capital flight, they might reduce their environmental standards to keep capital from moving out or to attract new investment, which is predicted by the “race to the bottom” theory. The “race to the bottom” or the “pollution haven” hypothesis is still in great controversy. Wheeler (2003), Eskeland and Harrison (1997) and many others argue that the empirical studies do not support this line of thought. Nonetheless, there are some studies showing evidence of support, for example, Smarzynska and Wei (2001), Xing and Kolstad (1998). This hypothesis actually reveals the relationship between level of production and level of pollution from a different angle: countries with lower environmental standards are usually countries with low incomes, the investment from the polluting industry will degrade the environmental quality in these countries. While for higher income countries from which these dirty industries come, the environmental quality will be improved, if they do not relax their environmental standards.

In short, the production level is a function of both pollution level, *d*, which in turn is a function of e, and GDP per capita. Because the business tax is based on the manufacturing level, we have that the business tax is a function of both e and GDP per

capita *I*, namely, $V = V(e, I)$.[79] Therefore, we have $V_e^{'}(e, I) < 0$, which captures the effects of government behavior of pollution control on the business tax. To expand the tax base and gain higher tax revenue, the government has incentives to lower e.

On the other side of Leviathan's revenue coming from the property tax, two factors should be examined carefully. First, the higher production level is not a free lunch. Though a higher-level production can expand the base of the business tax, the pollution coming with it will damage the value of the real estate properties. This would lower Leviathan's revenue from property tax, given property tax rate τ_p. Therefore, the property tax base is a function of government efforts to control pollution. We assume $P_e^{'}(e) > 0$ before some point and $P_e^{'}(e) < 0$ after that. The reason P is concave in e is that when e increases initially, pollution decreases and the value of property goes up. When e, however, is too high, the production level becomes lower, which means that the environmental restrictions put too much pressure on production activities and even lead to the exit of some firms. The pessimistic prospect for the job market drives people away to other localities, and then the demand on the property, such as housing, will be lower, which will lead to the drop in property value. Second, the value of property is significantly influenced by GDP per capita. The property value will increase as GDP per capita increases. To model the effects of these two factors, we have the following equation, namely, $P = P(e, I)$. Therefore, we will have $\frac{\partial p}{\partial e} > 0$ before some point and $\frac{\partial p}{\partial e} < 0$ afterwards. Also we have $\frac{\partial p}{\partial I} > 0$.

[79] We need to note that the relationship between *V* and *I* is non-linear.

About the demand for health care, *H*, we also need to consider two factors. The first one is still the pollution level. In order to harvest the revenue increase resulting from the boom in the production level, however, the government needs to pay a price that it may face a bigger heath bill resulting from the higher pollution levels, since higher-pollution level can expose residents to an unhealthier environment and they will have a higher chance of getting sick., No matter to what extent a government spends on the health care service for its residents, increased pollution will more or less drive up public health expenditure since it is one of the basic public services governments are obligated to deliver. What is more, a small increase in the pollution level can possibly significantly increase the chances of residents being negatively affected by the pollution. So the government's expenditure for health protection is also a function of government efforts to control pollution e. We will have $H_e^{'}(e) < 0$ and $H_e^{''}(e) > 0$.

The demand for health care is a normal good in the sense that as people get richer, namely, as GDP per capita increases, they will usually demand more and better health care services. Meanwhile, government has more resource available and so is able to spend more on health care as income increases. So the demand for health is a function of both the government efforts of pollution control and GDP per capita, $H = H(e, I)$.

In the context that we discussed above, the Leviathan's problem becomes the following

$$\underset{e}{Max} \quad \alpha \cdot \tau_v \cdot V(e,I) + \beta \cdot \tau_p \cdot P(e,I) - \gamma \cdot H(e,I) - G \qquad (1)$$

Where τ_v is the tax rate for the business tax, τ_p is the rate of property tax.

α, β and γ are pre-determined parameters, measuring the extent of the government levy taxes on the economic resource and the extent of the government taking care of the health of the residents. For example, the Leviathan government may be obligated to pay the entire health care bill; or, alternatively, the Leviathan may decide to pay nothing. If γ is defined as the share of health care expenditure the Leviathan takes as its responsibility, $\gamma \in [0,1]$. If $\gamma = 0$, the government pays nothing for the health bill. If $\gamma = 1$, then the government pays the entire bill.[80] Same are true for α and β, which can be taken as the weights of revenue sources given to the business tax and property tax, respectively. Similarly, if $\alpha = 0$, the government does not levy the business tax; if $\alpha = 1$, then the government exhibits a fierce collection on the business tax. If $\beta = 0$, the government does not levy property tax; if $\beta = 1$, then the government relies heavily on property tax as its revenue source and therefore exerts great collection efforts.

The first-order condition (FOC) to this revenue maximization function is[81]

$$\alpha \cdot \tau_v \cdot V_e^{'}(e,I) + \beta \cdot \tau_p \cdot P_e^{'}(e,I) - \gamma \cdot H_e^{'}(e,I) = 0 \qquad (2).$$

The government behavior on the efforts of pollution control is governed by the FOC (2). From the above equation, e can be denoted as a function of all the other variables in (2)

[80] Here the case of health care is different in that usually governments are paying more or less for the health care of the resident, therefore in general we should expect $0 < \gamma < 1$; unlike the weights to VAT and property tax, which can take the value of zero since some countries don't levy VAT or property tax. We don't differentiate here.

[81] The last term in the object function disappears in the FOC because, according to our assumption, that G is not related to the government efforts e.

$$e = e(I, \tau_v, \tau_p, \alpha, \beta, \gamma) \qquad (3)$$

From this revenue maximization problem, we can derive the following propositions:

Proposition I, for any given per capita income I , budget structure or the constitution in the sense of the first essay matters in pollution control. The effort devoting to pollution control, and therefore, according to our assumption, the pollution level, is determined by the constitution. The constitution, following what we used in the first essay, states whether government has business taxes or residential taxes, and how obligated it is to provide services to mediate the health effects of pollution, and etc.

Proposition II, for any given per capita income I , if $\alpha > 0$, $\beta = 0$ and $\gamma = 0$, the revenue maximizing Leviathan will have no incentive to control pollution. For the proof, please see the Appendix B-1

Proposition III, for any given per capita income I , if $\alpha = 0$, $\beta > 0$ and $\gamma > 0$, and the pollution level is high (which means e is low), the Leviathan will have strong incentives to control pollution. But the extent of pollution control is subject to some constraints and can not be too high. There exists an optimal level of pollution control. For the proof, please see the Appendix B-2.

If all the three parameters α , β and γ are in the range of (0, 1), without taking the extreme values, we would expect the optimal level of pollution control is achieved by balancing the revenue and expenditure associated with the pollution level. Specifically, the optimal condition is governed by the FOC (2) above, or

$$\alpha \cdot \tau_v \cdot V_e^{'}(e,I) + \beta \cdot \tau_p \cdot P_e^{'}(e,I) = \gamma \cdot H_e^{'}(e,I) \qquad (2')$$

As the pollution affects government behavior from both the revenue side and the expenditure side of the budget, the interaction between the two sides of the budget makes the problem even more complicated. For example, if a government does not need to spend much on healthcare and relies heavily on the pollution production activities (from which government can collect the business tax), it may even try to attract those high-pollution industries into its jurisdictions in order to increase their tax bases. Bidding for "dirty" industries could be a "good choice" under those circumstances, given the assumption of government strategic behavior. However, if with the same level of expenditure responsibility on health care, while most tax revenue is from property tax, the government will be interested in maintaining higher environmental quality. We can see the outcomes of the interaction more clearly through the following table.

Table A Different Incentives under Different Budget Structures

		Share of Public Health Expenditure	
		High	Low
Main Component of Revenue Source	Tax collected from pollution production activities (Business related taxes)	Trade-off	Lowest incentives
	Property tax	Highest incentives	Trade-off

According to the Table above, we will expect some interactions between budget structure and government behavior of pollution control. The model above covers the relationship among business related taxes, the property tax and health expenditure and their interaction in a comprehensive framework. To summarize, if we make the assumption that the government's effort of pollution control can effectively achieve desired pollution level, we can formulate the following three hypotheses,

Hypothesis I:

Higher proportion of tax revenue collected from business related taxes gives government weaker incentives to protect environment quality. Therefore, higher ratio of business related taxes over total tax revenue will result in lower effort of pollution control and higher pollution level.

Hypothesis II:

Higher proportion of tax revenue collected from property tax gives government stronger incentives to protect environment quality. Therefore, higher ratio of property tax over total tax revenue will result in higher effort of pollution control and lower pollution level.

Hypothesis III:

A fuller assignment of expenditure responsibilities on health gives government stronger incentives to protect environment quality. Therefore, the higher the ratio of public health expenditure over total expenditure, the stronger incentive of pollution control and the lower the pollution level.

In the following section, we test empirically the three hypotheses using a cross-section time series data set.

Data and Methodological Issues

Model specifications

Starting from our previous hypotheses, we investigate whether differences in the budget structure have an impact on the government's incentive to control pollution. More specifically, we want to see how effort towards pollution control, and therefore in turn, how the pollution level is affected by the incentives from the budget structure, exemplified by the shares of business related tax and property tax in total tax on the revenue side, in conjunction with the share of health expenditure in total government expenditure on the expenditure side.[82] Thus, our equation takes the following form:

$$M_{i,t} = f(\mathrm{Re}v, Exp, Gov, Control) \qquad (1)$$

where $M_{i,t}$ is the level of total emissions for the aforementioned four air pollutants, *Rev* is a vector of variables that affect level of pollutions from the revenue side of the budget, *Exp* includes variables from expenditure side of the budget. *Gov* is a vector that captures the characteristics of the government, and *control* includes some variables controlling for the basic conditions of the country. We will explain the relevant variables included in each of these categories below.

In order to capture the effects of incentives on the revenue side on the government behaviors, we use both data on business related taxes and property tax in our

[82] This is under the assumption that the government's policy can always achieve the desirable outcome.

estimation. Therefore, *Rev* includes *Iratio*, *Cratio* and *Lratio*. *Iratio* is the ratio of revenue from business related taxes over total revenue. According to our hypothesis I, the expected sign for the coefficient on this variable is positive in that higher ratio of business related taxes will lead to a lower effort of pollution control and thus a higher pollution level, due to the government's motive of pursuing higher tax revenue.

For property tax, the ratio of property tax over total revenue at both the central level and local level are adopted, since in our sample, property tax either constitutes the main revenue source of local government, or goes to the central government's coffer.[83] We use *Cratio* to denote the ratio of property tax over total tax revenue collected by central government and regional government. *Lratio* is the ratio of locally collected property tax over total local government tax revenue. According to our hypothesis II, the expected signs of *Cratio* and *Lratio* are both negative. Our earlier analysis argues that the damage to the property tax is more evident at the local level; therefore we would expect the effect of *Lratio* to be more important. In other words, a bigger share of property tax in local tax revenue would lead to the local government to exert a higher effort of pollution control, and therefore result in a lower pollution level, and *vice versa*. The property tax ratio for the central and regional governments might not have the same effects, since the higher level government has a broader tax base than local government, and the negative consequence of pollution on property tax base will not be as substantive.

[83] In a lot of countries, government is divided into central, regional (state or province,), and local government. In that case, we group central and regional government into central government.

In order to capture the effects of pollution on the expenditure side of government behavior, we use the ratio of government' healthcare expenditure over total public expenditure, *Hratio* in *Exp* in equation (1).[84] This variable measures to what extent the government is allocating fiscal resources to healthcare. A higher *Hratio* means that governments spend higher shares of resources on public health services; thus the government will have incentive to exert higher efforts to control pollution, in order to save on the expenditure outlet. Lower *Hratio* means that governments do not have obligation to spend much on public health, and thus have less incentive to control pollution. We anticipate this variable to have a negative effect, meaning a higher share of public expenditure on healthcare would give government more incentive to lower the pollution level.

As mentioned above, the EKC hypothesis does not take into account the role of the government. However, in our framework, we are trying to identify whether governments play important roles in influencing environmental performance. One of the important policy conjectures we can investigate is whether the relationship between budget structure and government incentive in pollution control is more evident in democratic countries than in non-democratic countries. In order to test whether or not the political characteristic of the government play a role in the process of pollution control, we include a variable *dem*, which measures the extent of democracy in the country.

[84] Our data set doesn't differentiate between local government's healthcare expenditures and those of the central government, mainly due to the data availability. Actually in most of the countries, central governments are at least partially responsible for the healthcare, except in very few countries such as China.

Following this line of analysis, it will also be helpful to control for the quality of governance. In our model we assume that the government intention of pollution control, and the policy instruments governments employ can achieve the desirable outcomes. This is a very strong assumption, and empirically we can relax it. In order to do this we need to control for some measure of governance. Only countries with good governance can possibly achieve the desired policy objectives. In our context, only countries with good governance can achieve the goal of reducing pollution to the desired level, a point that Dasgupta, et al (2004) make in their study. In a country with corruptive government, even when it has the incentive to control pollution, it might not be able to achieve the goal. Here we use *cpi,* the corruption perception index as the measure of governance. Both *dem* and *cpi* are included in *Gov* in equation (1).

In addition, we include in our model some other variables to control for the characteristics of each country, which we denote in the model with *Control*. Firstly, in our model, per capita GDP enters our regression. We assume that, as a public good, environmental quality is a normal good. In other words, as GDP per capita increases, the demand for environmental quality also increases (North 1990), and government is not only obligated to provide better quality of environment, but also can afford to do so when income level is higher. Therefore, GDP per capita enters our regression as an explanatory variable, denoted by *pgdp*. We also control for population in a country, *pop,* since more population will bring about possibly more economic activities and thus more pollution than countries with less population. But if population is spread out in a big country,

pollution should be lower than when population is concentrated in a small country. From this perspective, the land area, *land*, is included in the model. We include each variable separately.

Therefore, with all variables explicitly, our model takes this reduced form:

$$M_{i,t} = \beta_1 + \beta_2 Iratio_{i,t} + \beta_3 Cratio_{i,t} + \beta_4 Lratio_{i,t} + \beta_5 Hratio_{i,t} + \beta_6 dem_{i,t} + \beta_7 cpi_{i,t} + \beta_8 pgdp_{i,t} + \beta_9 land_i + \beta_{10} pop_{i,t} + v_{i,t} \quad (2)$$

In our model, the $v_{i,t}$ is a composite error term, which can be alternatively formulated in a way that includes country heterogeneity, which we denote by c_i, and $u_{i,t}$, the idiosyncratic disturbance term. c_i captures country specific effects that do not vary over time. Usually for time series cross sectional data, we would also consider time effect, which changes over time. However, as we will see later on, we have few countries for which many time periods of data are available, so we mostly conduct one-way error component analysis.

Data

Environmental Indicators

In the prevailing EKC literature, different kinds of pollutants are used to test the validity of the reversed U shape phenomenon, including air pollutants, water pollutants, deforestation, and so on, with a special interest in air pollution. We follow this tradition and use air pollution data to do our empirical test. Here for our purpose of empirically investigating the relationship between budget structure and environmental performance, we choose the following pollutants NOx, CO, SO_2 and CO_2 as our environmental

indicators. The reason is that they have different environmental and health impacts. According to the US Environmental Protection Agency (EPA), six principal pollutants considered harmful to public health and the environment, also called "criteria" pollutants, have been set in National Ambient Air Quality Standards: Ozone, Particulate Matter (PM), Carbon Monoxide (CO), Nitrogen Dioxide (NO_X), Sulfur Dioxide (SO_2) and lead. We obtain cross sectional time series data for three of them, NO_X, CO and SO_2. In addition, CO_2 is included due to the fact that data for CO_2 is the most readily available. Even though it does not damage human health in any direct way, it is the major contributor of global warming and has significant impact on environment. Due to their different impacts on human health as well as on environment, government may have different incentives in controlling their emission levels.[85] Also due to the different properties of these pollutants, aggregating might obscure some of the individual effect. Therefore, we will look at the relationship between pollution level and budget structure of each pollutant separately. Most of the EKC literature deals with individual pollutants, too.

Mainly due to data availability, we do not make distinctions whether these pollutants are from production process or other processes, and use the total yearly emissions of a particular pollutant in a country instead. This could bring about potential

[85] According to the information on the EPA website, CO affects human health by reducing the level of oxygen delivered. It is especially harmful to people with heart disease if at lower level, but will harm healthy people at high level. It also contributes to smog formation. NO_x has serious health and environmental effect since the nitrogen oxides family has a lot of compounds and derivatives that contribute to smog, acid rain, particles that deteriorate human health, worsening water quality, global warming, formation of toxic chemicals, and leading to visibility impairment. SO_2 affects human health by damaging respiratory organs and functions. It is also conducive to the formation of acid rains, accelerating the decay of building and statute, changing negatively water and plant system and so on. For more detail, please visit http://www.epa.gov/air/urbanair (last accessed on Dec. 05, 2005).

measurement error problems since air pollutants can flow across countries and total emissions might not accurately measure the extent of the pollution in a country at some point of time. A similar issue is that pollution can flow across different regions within a country, thus emissions at national level will not capture the extent of the pollution in different localities.[86] Nonetheless, keeping these points in mind, the measure of total emissions should provide us a starting point for the relationship between pollution level control and government budget structures.

Data Sources

The data used in our empirical analysis come from several different sources. The data of dependent variables, level of pollutants including CO, NO_x and SO_2 are from United Nations Framework Convention on Climate Change (UNFCCC), Greenhouse Gas Inventory (GHG) Database, including data for a total of 108 countries, during the year of 1990-2002.[87] In addition, we obtain CO_2 data from the World Development Indicator (WDI), 2004. The pollutant data from UNFCCC are measured by total emission for a particular pollutant with the unit of gigagram, which is an equivalent measure of thousand metric tons that is used for CO_2 from WDI.[88]

The data for the explanatory variable, ratios of taxes on the revenue side of the budget, *Iratio, Cratio* and *Lratio,* are from IMF Government Finance Statistics (GFS). We use the general value added, sales, or turnover taxes in GFS as the measure of

[86] In this sense, it is reasonable to take into consideration the geographical characteristics of a country, as Dasgupta, et al (2004) and others did in their works. We didn't control this, nor could we carry out spatial analysis due to the limit of our dataset and the unbalanced nature of it.
[87] The GHD database contains more than 108 countries, but we leave out those countries with too limited data, and we end up have 108 countries.
[88] The UNFCCC includes data for CO_2 as well. However, data from WDI give us more observations. Therefore we use CO_2 from WDI instead.

business related tax in our estimation, thus the *Iratio* is the share of general value added, sales, or turnover taxes over total tax revenue. *Cratio* and *Lratio* are the shares of property tax in total tax at the central (and regional) and local level, respectively. The data for expenditure side of the budget, the expenditure ratio of central government on the health over total expenditure, *Hratio*, is from various issues of World Health Report published by World Health Organization (WHO).

For the measure of government, *Gov* includes two variables, *dem* and *cpi*. The measure of democracy, *dem* is calculated with the two measurements of freedom from the "Freedom in the World" survey by the Freedom House: political rights and civil liberties. The former measures how freely people are involved in the political process, while the latter measures individual freedom of expression, rule of law, etc. Both of these two measurements are measured on a scale of 1 to 7, with 1 denoting highest freedom. In order to capture the freedom both in the political sphere and personal life, we follow Dailami (2000) and use linear combination of these two to convert the measure of freedom to be within the range of [0,1], with 0 denote the least free.[89] Since people from democratic countries generally enjoy more freedom than people from non-democratic countries in that in the latter, the authoritarian way of decision making deprives people of much freedom, we use the extent of freedom to measure the degree of democracy. This measure of democracy gives a rough idea of how democratic the country is from a special angle.

[89] The formula Dailami (2000) used to convert is Dem = (14- score of political rights – score of civil rights)/12 .

The other measure of government, *cpi,* corruption perception index, is from Transparency International (TI). This measure is a survey-based composite measure of the extent of corruption, instead of a comprehensive measure for the quality of governance, which can not provide a precise measure whether or not an intended policy can achieve desired results; therefore it might not be an ideal proxy for our purpose. In addition, the index measures how corrupted countries are perceived to be, which not only gives the *cpi* an ordinal nature, but also makes it vulnerable to the cultural, democratic and economic backgrounds of the businesspeople and country analysts being surveyed as well as to the survey methodology change over time. However, this measure focuses on public sector corruptions, defining corruption as the "abuse of public office for private gain," which at least partially possesses the characteristics of the governance indicator that we are trying to capture.[90] Besides, compare with other measures, this index gives us more degrees of freedom.[91]

For the control variables, *Control* includes GDP per capita, land areas, and population, which are all from WDI, 2004. Table 1 shows the descriptive statistics of the variables used in the estimation. More detailed explanations of each variable are presented in Table 2.

We adopt panel data estimation because it has the advantage of pooling cross-section and time series data and thus increases degrees of freedom, which not only

[90] This is according to the definition of TI.
[91] Other measurements include for example, the corruption control composite by Kaufmann in the WBI, which is released biannually, from 1996-2004.

mitigates our problem with limited data, but also partially deals with potential omitted variable bias by controlling for unobserved effects (Baltagi 2001; Wooldrige 2002).[92] Ideally we would have data for 108 countries spanning over years 1990-2002. However, missing values especially for the dependent variables and tax variables leave us unbalanced panel dataset with at best less than 100 observations.

A closer look at the dataset gives us a clearer idea of what data we can actually use in our estimations. Among the four pollutants we are working with, CO_2 has the biggest sample size; NO_x and CO has the same size, while the size for SO_2 is the smallest. Due to missing values, for most countries our data do not have many time periods available. The availability of the pollutants data and the tax data enable us to estimate the relationship between tax structure and pollution level within the range of 1995 to only 2000 for CO_2 and to 2001 or 2002 for the other three. Few countries have data available for all these years. Countries with longer horizons in the dataset include only Canada, Czech Republic, Denmark and Switzerland for NO_x and CO (less Canada for SO_2), and include additionally 5 countries including Bolivia, Mexico, Norway, Poland and Thailand for CO_2. These limits on the data restrict us from applying more estimation techniques and favor performing some of the specification tests. Consequently, as we will see later, we empirical estimations are based on simple regressions.

Empirical Estimation Issues

[92] In theory panel data can achieve this; however, it is not necessarily as effective for our dataset, due to the poor quality of our dataset. Nonetheless, it can at least partially remedy the problem.

Econometric Estimation Issues

Endogeneity Problem

There are some potential endogeneity problems in our estimations. Our model predicts that as the share of health expenditure in total public expenditure, *Hratio* rises, the government will have greater incentive to control pollution, and therefore the pollution level should be lower. However, the high *Hratio* could be the consequence of high pollution level: when more people get sick because of the increased pollution level, government will have to spend more on health care and thus drive up *Hratio*. If this relationship is true, then we will encounter an endogeneity bias in our regression.

To deal with this potential endogeneity problem for ratio of health expenditure, we use a Hausman test to test for endogeneity, using as an instrument life expectancy at birth.[93] Following Castineira and Nunes (1999), Posnett and Hitiris (1992) and others, we tried different instrument variables, including share of population over 65 in total population, number of physicians in per 1000 people, number of hospital beds in per 1000 people, share of education expenditure in total expenditure, share of military expenditure in total expenditure, and etc. Only share of education expenditure and life expectancy at birth are significant in the first stage regression. We finally choose life expectancy at birth as our instrument because education expenditure imposes further

[93] The life expectancy at birth and all other variables are from World Development Indicator (WDI), 2004.

restrictions on our sample size in the regression. In Table 3, we can see that the life expectancy at birth is significant in the first stage regressions for all four pollutants.[94]

The null hypothesis for the Hausman is that the estimates from OLS and instrumental variable are not significantly different from each other. If we do not have evidence to reject the null of no difference, it is possible the OLS estimates are not badly biased. As illustrated in the last two rows in Table 3, in our estimations, the test statistics we obtain are not significant to reject the null for any of the four pollutants. Thus we can draw the conclusion that in our sample, there is no evidence of endogeneity.[95]

Fixed Effects vs. Random Effects

We can write our model in the general form

$$y_{i,t} = X_{i,t}\beta + v_{i,t} = X_{i,t}\beta + c_i + u_{i,t}$$

For the panel dataset we have, the first thing we need to decide is whether we should choose fixed effects regression or random effects regression. The key criterion is whether unobserved effects $c_{i,}$ or the country heterogeneity is correlated with the explanatory variables $X_{i,t}$. If c_i is orthogonal to or uncorrelated with the explanatory variables, we can treat c_i as random by putting c_i into the error term. The appropriate estimator is generalized least squares (GLS) estimator based on the composite error

[94] Since all the explanatory variables are the same for all four pollutants, we should obtain the same results in first stage regressions in all cases. However, our sample sizes are different among different pollutants, which explains why the results are the same only for NO_x and CO, while for SO_2 and CO_2, results are different.

[95] Note this Hausman test is sensitive to the chosen instruments. If the instrument is poor and the test statistic lacks power, it will not be able to reject the null and the model will be misidentified due to the presence of the endogeneity problem.

term $c_i + u_{i,t}$.[96] If c_i is correlated with the explanatory variables $X_{i,t}$, then fixed effects regression is necessary.

In considering the roles of geographical characteristics play in affecting pollution level, we believe fixed effects regression be better to account for these effects that are not changing over time. However, lack of data makes it infeasible to conduct fixed effects regression. Therefore, we assume that in the general form model, c_i is uncorrelated with the explanatory variables and apply random effects regression.

Error Structure

Another important issue is that because different components of the dataset are from different data sources, thus we would not expect that error terms to possess the property of $E[v] = 0$ and $Var[v] = \sigma^2$. Recall that *v* is the composite error, and almost certainly $E[v_i^2] \neq E[v_j^2]$. If we follow most of the EKC studies and do OLS regressions, heteroskedasticity problem will arise and consistent but inefficient estimates will be produced, which raises the necessity of testing for the heteroskedasticity. We use the robust standard errors to correct for the heteroskedasticity in our pooled least squares regressions. In the panel data regressions, we also correct for heteroskedasticity by feasible generalized least squares (FGLS), assuming the idiosyncratic error terms take some special structures, which we will discuss in more detail in Appendix A.

Additionally, due to the time series in the data, there is a potential dynamic process. The emissions in this year could be due to the same reasons for the emissions

[96] As we will explain in detail later, the way of treating $u_{i,t}$ can take the general form or random effect regressions.

last year, or the year before. Due to the limitations on our dataset, we do not have sufficient time series data to deal appropriately with the dynamic structure, but hope we can remedy this in the future once better data become available.

Regression Results

We use several estimation strategies. First, in order to compare our hypothesis with those original EKC studies, we follow Panayotou (1993)'s estimation model to examine the relationship between pollution indicators and GDP, GDP square with our data. From the outcomes we can determine if our data provide support to the EKC hypothesis. However, even though we are following the log linear functional form, we need to be mindful that the data we used in this study is different from what Panayotou used in 1993 since we have an unbalanced panel dataset.

Therefore, first we estimate the following equation using the total emissions of pollutants:

$$Ln(M_{i,t}) = \beta_1 + \beta_2 pgdp_{i,t} + \beta_3 (pgdp_{i,t})^2 + \varepsilon_{i,t} . \qquad (3)$$

Here M_i are the emission levels of CO, CO_2, NO_X and SO_2, *pgdp* is per capita GDP.[97]

Our results show that our data set are conformable to the EKC framework in that all the quadratic forms are negative. We report the results for these regressions in Table 4.

Then we test the three hypotheses by adding the six variables *Iratio, Cratio, Lratio, Hratio, dem* and *cpi*, as well as some control variables that we mentioned earlier, to the list of explanatory variables and estimating the following equations:

[97] From here we can see that our equation is different from what Panayotou (1993) used in his paper.

$$Ln(M_{i,t}) = \beta_1 + \beta_2 Ln(Iratio_{i,t}) + \beta_3 Ln(Cratio_{i,t}) + \beta_4 Ln(Lratio_{i,t}) + \beta_5 Hratio_{i,t}$$
$$+ \beta_6 Ln(dem_{i,t}) + \beta_7 Ln(cpi_{i,t}) + \beta_8 Ln(pgdp_{i,t}) + \beta_9 Ln(land_i) + \beta_{10} Ln(pop_{i,t}) + v_{i,t} \qquad (4)$$

We still follow this log linear functional form, taking the logarithm of the dependent and independent variables except for the ratio of health expenditure.[98] We estimate 4 different models for each of the pollutants here. Model 1 is the pooled OLS regressions. Model 2-4 are the random effects regressions, since, as we tested earlier by Hausman specification test, random effects are preferable to fixed effects for our data.[99] Model 2 and model 3 are the traditional random effects regressions, a special form of feasible generalized least squares (FGLS), which takes the country heterogeneity into account and we take to be the most appropriate models for our dataset. The difference between model 2 and 3 is that in model 3, we include a time trend to account for the time specific effects. Model 4 is the more general form of FGLS regressions. In the Appendix A, we explain in more detail the difference between the special FGLS, the random effects model (REM) in model 2 and 3 and the general FGLS in model 4.We assume the error structure is heteroskedastic and try to correct for the potential heteroskedasticity in model 4. The results are presented in Tables 6-9.

From Table 5 we can see that, in all 4 models, the share of business related taxes has a positive and statistically significant impact on pollution levels, which provides support to our hypothesis I. Since we are using logarithm transformations, it is easier to interpret the results. We can see the magnitude of the relationship between pollution and

[98] Usually we don't take logarithm of ratios. In considering of the relationship between pollution level and ratio of taxes is not linear, we multiply the tax ratios by 100 and then take logarithm of them.
[99] Except for SO_2 that is weakly significant, as we discussed before.

business tax ratio ranges from 1.29-1.98 percentage points, which means that the increase in one percentage point in business tax ratio will result in pollution level increase by 1.29-1.98 percentage points. The effects of property tax share at local level have small, but negative and significant impacts, which support our hypothesis II. The magnitude ranges from 0.3-0.4 percentage points. Coefficients of property tax ratio at central and regional level are mixed and imprecisely measured, which conformsto our earlier conjecture. Ratios of health expenditures always correctly give negative signs, usually with a magnitude of much bigger than business tax ratio and local property tax ratio except in model 3, even though only in model 4 is it significant.[100] This provides some supporting evidence for our hypothesis III.

The measure of democracy gives us systematically positive signs. This suggests that with this measure of democracy, we can say that the environmental policy control is performing worse in democratic countries than in non-democratic countries, at least with the pollution data of NO_x in our sample. Given our results, it seems that the incentive of tax structure on government's pollution control works better in non-democratic countries. The measure of governance, corruption perception index, gives mixed results. In the first 3 models, the coefficient signs are negative, meaning countries with good governance should have better environment or less pollution, but the effects are not significant. One explanation might lie in the inadequacy of our dataset; in particular, our sample size may

[100] We did not take the logarithm of the health expenditure ratio, therefore we need to take caution when interpreting and comparing the results.

not be large enough. In addition, these two measures might not be able to capture the political characteristics and quality of governance very well. We hope that better measurements can be used in the future.

For the control variables, population and per capita GDP are always positive and significant, meaning more populated countries and richer countries have higher level of pollution, which is intuitive. Given the high correlation between per capita GDP and democratic measure, our positive results of democracy are not a surprise: countries with higher income are usually more democratic, and also these countries have more serious pollution problem.[101] Land area is always negative and mostly significant, suggesting that NO_x gets dispersed as the country becomes bigger. The time trend in model 3 is negative and significant, meaning level of NO_x decreases over time. As we will observe later, for the other three pollutants, time trends always exhibit a strong negative pattern.

From Table 6 we can see that, for the pollutant CO, we generally have the similar story as NO_x, with smaller magnitude for business tax ratio and similar for central (and regional) property tax ratio and health expenditure ratio. But in the two random effects models 2 and 3, business tax ratios are not significant. In addition, local property tax ratio and per capita GDP do not have expected good and significant results; neither does the land area exhibit the strong relationship as it does for NO_x. However, the health expenditure ratio is always negative and significant in two out of the 4 models. Results

[101] The pair wise correlation between per capita GDP and democracy is 0.585, and highly significant.

for democracy and corruption perception index are still mixed, and usually the coefficients are not significant.

Table 7 indicate that, the results for SO_2 are not as good as those for NO_x and CO. The coefficients for business tax ratio differ by big scales depending on model, while the local property tax ratio and health expenditure ratio exhibit the similar trend as NO_x and CO. The business tax ratios are only positive and significant in model 1. Ratios of property tax at local level have correct signs only in model 3 but not significant. Health expenditure ratio is only significant in the random effects model 2, even though it is negative in 3 of the 4 models. However, the unexpected big magnitude of the coefficient in model 2 is suspicious. For democratic measures, the coefficient gives negative signs in all 4 models in this case, meaning that the democratic countries control emissions of SO_2 better than non-democratic countries, however the signs are not significant. For governance measures, except in model 2, we usually have positive and significant coefficients. According to this, countries with good governance or less corruption will have higher levels of SO_2. Per capita GDP usually has significantly negative signs in this case, which means richer countries tend to have less SO_2. When we take into account that richer countries usually are those countries with less corruption, we encounter a contradiction here. However, SO_2 is mainly from heavy industries and is different from other pollutants, which might be part of the reasons for the difference in the estimations. Besides, we have the smallest sample size for SO_2, which might contribute to these poor results. The time trend is again significantly negative.

Table 8 records the results for CO_2. We can see from this table that CO_2 is the pollutants that we have the biggest sample size. As it illustrated, business tax ratio are always positive, but only significant in model 4, with the scales smaller than the other pollutants. Different from the pollutants that we dealt with earlier, for CO_2, both property taxes at central and regional level and at local level are negative. Health expenditure ratio does not always exhibit negative signs as other pollutants do and the scales are smaller, too. This can be explained partly by the fact that CO_2 is not directly detrimental to human health, therefore it does not have as strong effects on health expenditure as other pollutants. Levels of CO_2 are surely higher where economic activities are more prosperous, as both people's livelihood and production activities contribute to the level of CO_2. However, due to the special role of CO_2 in greenhouse effects, it is one of the most important contributors to global warming, thus gives every level of government great incentives to control the emission level. The serious consequences of global warming make it even more important for the higher level government than for local government to control level of CO_2, which partly explains the different effects on property tax ratios for central and local governments from other pollutants. Measure of democracy does not give us systematic results in this case either. But corruption index are generally positive and significant in 2 models, meaning in countries with good governance or less corruption, level of CO_2 is higher, which is an unexpected result. Coefficients of population, per capita GDP, and land areas are generally positive and significant, meaning countries with more prosperous economic activities, higher population and

higher income usually have higher level of CO_2, which does not have the contradiction as in the case for SO_2.

Therefore, as a summary illustrated in table 9, we report the results from model 3, our preferred model, for all four of the pollutants that we are considering here. Most of our regressions provide evidence supporting our hypotheses, though in some cases the evidence is not very strong. We observe that higher ratio of business related taxes in tax revenue, lower share of property tax in tax revenue at local level, and lower share of public health expenditure over total public expenditure are associated with higher pollution level and vice versa. The strong time trends show that pollution decreases over time.

We could not obtain evidence whether or not the environmental policy is different for democratic countries and non-democratic countries, nor could we obtain the effect of governance on pollution control. These results call for better measurements. But meanwhile, it is possible that the incentive of budget structure to government environmental control works for both the democratic countries and non-democratic countries.

Conclusion

In this study we are trying to obtain evidences to support the proposition that the government budget structure can influence government incentives and therefore has effects on the provisions of public goods, with environmental quality as the example.

In conclusion, the empirical evidence we obtained in this study provides supports to our three hypotheses, even though the quality of the dataset and measurements of certain variables need improvement. We establish that the government incentives and budget structure can have some impacts on government behavior. And according to our empirical results, it works regardless of the political characteristics of the countries. Therefore, for the purpose of dealing with environmental problems, in addition to other direct and indirect regulations, incorporating government budget structure into the process of decision-making may be a good choice. More specifically, transition from relying on business related tax system to employ property tax to a broader extent and adopting government-financing healthcare system may be conducive to improving environmental performance. We can see that the policy implication of traditional EKCs that economic growth will cure environment problem by itself, and then “grow first, clean up later” is misleading.

Governments are the same as individuals and firms in that they all have their own interests and respond to different incentives. Government incentives and governments’ strategic behaviors under different incentive schemes should be given full consideration when making policy decisions.

Table 1. Summary of Statistics

Variable	Observations	Mean	Standard Deviations	Minimum	Maximum
Nitrogen Oxides (NO_x)	477	1129.89	3566.588	0.08	22860
Carbon Monoxide (CO)	478	5438.914	18040.28	0.02	130580
Sulfur Dioxide (SO_2)	409	1055.501	3097.563	0.01	20936
Carbon Dioxide (CO_2)	1136	144157.7	544707.8	0	5600000
Ratio of Business Tax	613	0.376824	1.347949	0	17.05926
Ratio of Property tax at Central Level	511	0.031641	0.033209	6.48E-06	0.171187
Ratio of Property tax at Local Level	378	0.476918	3.598491	7.99E-06	70.02703
Population	1404	2.40E+07	3.96E+07	770000	2.88E+08
Ratio of Health Expenditure	864	10.89664	4.519649	1.6	28.9
Democracy	1383	0.601772	0.307262	0	1
Per Capita GDP	1381	7001.864	10769.6	84.73576	46894.91
Corruption Perception Index	470	5.219468	2.463203	0.4	10
Land Area	1365	799957.1	2085717	670	1.69E+07

Table 2. Explanations of Variables

Variables	Label	Unit	Source
Pollution level measured by total emissions of NOx	NO_x	Thousand metric tons	United Nations Framework Convention on Climate Change (UNFCCC), Greenhouse Gas Inventory (GHG) Database
Pollution level measured by total emissions of CO	CO	Thousand metric tons	United Nations Framework Convention on Climate Change (UNFCCC), Greenhouse Gas Inventory (GHG) Database
Pollution level measured by total emissions of SO_2	SO_2	Thousand metric tons	United Nations Framework Convention on Climate Change (UNFCCC), Greenhouse Gas Inventory (GHG) Database
Pollution level measured by total emissions of CO_2	CO_2	Thousand metric tons	World Development Indicator Database (WDI), 2004
Ratio of VAT revenue in total tax revenue	Iratio	in percentage	IMF Government Finance Statistics (GFS), 2004
Ratio of central property tax revenue in total central revenue	Cratio	in percentage	IMF Government Finance Statistics (GFS), 2004
Ratio of local property tax revenue in total local revenue	Lratio	in percentage	IMF Government Finance Statistics (GFS), 2004
Population	pop	No. of people	World Development Indicator Database (WDI), 2004
Ratio of public health expenditure over total public expenditure	Hratio	in percentage	Various issues of World Health Report published by World Health Organization (WHO)
Democracy	dem	[0,1]	Freedom House
Per capita GDP	pgdp	In constant 1995 dollars	World Development Indicator Database (WDI), 2004
Corruption perception index	cpi	[0,10]	Transparency International
Land areas	land	Square kilometers	World Development Indicator Database (WDI), 2004

Table 3. Endogeneity Test Results

	NO_x	CO	SO_2	CO_2
	First stage results:			
	Dependent variable: Ratio of Health Expenditure			
Ratio of Business Tax	-0.514	-0.514	-2.115	-0.544
	(0.55)	(0.55)	(1.57)	(0.56)
Ratio of Property tax at Central Level	0.254	0.254	0.238	0.327
	(1.05)	(1.05)	(0.98)	(1.17)
Ratio of Property tax at Local Level	-0.893	-0.893	-0.620	-0.987
	(2.60)***	(2.60)***	(1.62)	(2.64)***
Population	0.004	0.004	-0.497	0.100
	(0.01)	(0.01)	(0.87)	(0.20)
Life Expectancy at Birth	0.674	0.674	0.711	0.539
	(3.21)***	(3.21)***	(3.30)***	(2.18)**
Democracy	-1.583	-1.583	1.356	-4.880
	(0.17)	(0.17)	(0.14)	(0.49)
Per Capita GDP	-0.705	-0.705	-1.471	-0.593
	(0.99)	(0.99)	(1.72)*	(0.56)
Corruption Perception Index	0.040	0.040	1.132	0.487
	(0.03)	(0.03)	(0.80)	(0.26)
Land Areas	0.123	0.123	0.705	0.142
	(0.43)	(0.43)	(1.52)	(0.48)
Constant	-28.739	-28.739	-20.221	-22.198
	(1.89)*	(1.89)*	(1.27)	(1.32)
Observations	54	54	50	48
R-squared	0.62	0.62	0.61	0.64
IV test χ^2	1.28	4.08	0.00	1.50
P-value	0.9985	0.9060	1.000	0.9972

Absolute value of z-statistics in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 4. Simple Regressions Testing EKC Hypothesis

	(1)	(2)	(3)	(4)
	Log of NO_x	Log of CO	Log of SO_2	Log of CO_2
Per capita GDP	0.012	0.007	0.012	0.019
	(5.17)***	(2.93)***	(3.80)***	(8.35)***
Square of per capita GDP	-0.024	-0.019	-0.036	-0.030
	(5.38)***	(4.12)***	(6.19)***	(6.51)***
Constant	4.102	6.458	3.803	8.884
	(19.67)***	(30.47)***	(11.65)***	(43.64)***
Observations	472	473	404	1120
Number of Countries	96	97	69	106

Absolute value of z-statistics in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 5. Regression Results for NO_x

	Model (1) Pooled OLS With Robust se	Model (2) RE	Model (3) RE w/Time Trend	Model (4) FGLS/Hetero
	Dependent Variable: Logarithm of NOx			
Ratio of Business Tax	1.982	1.287	1.448	1.945
	(6.94)***	(2.83)***	(3.39)***	(9.65)***
Ratio of Property tax	0.004	-0.020	-0.032	-0.007
at Central Level	(0.12)	(0.26)	(0.45)	(0.25)
Ratio of Property tax	-0.394	-0.300	-0.360	-0.357
at Local Level	(4.59)***	(1.97)**	(2.51)**	(6.03)***
Ratio of Health	-0.048	-0.071	-0.001	-0.048
Expenditure	(1.50)	(1.40)	(0.01)	(2.38)**
Population	1.515	1.409	1.374	1.477
	(19.29)***	(8.75)***	(9.21)***	(24.21)***
Democracy	1.557	0.412	0.659	1.699
	(3.39)***	(0.50)	(0.81)	(2.41)**
Per Capita GDP	0.472	0.572	0.437	0.394
	(3.46)***	(2.37)**	(1.85)*	(4.55)***
Corruption Perception	-0.066	-0.263	-0.092	0.274
Index	(0.17)	(0.70)	(0.24)	(1.37)
Land Area	-0.321	-0.390	-0.345	-0.285
	(3.62)***	(2.81)***	(2.66)***	(3.89)***
Time Trend			-0.073	
			(1.97)**	
Constant	-24.170	-20.003	-19.617	-23.794
	(9.69)***	(4.77)***	(5.01)***	(13.93)***
Observations	64	64	64	64
R-squared	0.90			
Number of Countries		18	18	18

Absolute value of t-statistics in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 6. Regression Results for CO

	Model (1) Pooled OLS With Robust SE	Model (2) RE	Model (3) RE w/Time Trend	Model (4) FGLS/Hetero
	Dependent Variable: Logarithm of CO			
Ratio of Business Tax	0.619	0.312	0.502	0.827
	(3.05)***	(0.75)	(1.42)	(7.05)***
Ratio of Property tax	0.028	-0.004	-0.010	0.018
at Central Level	(0.86)	(0.06)	(0.16)	(0.87)
Ratio of Property tax	-0.119	0.001	-0.056	-0.134
at Local Level	(1.21)	(0.00)	(0.48)	(3.02)***
Ratio of Health	-0.072	-0.056	-0.004	-0.091
Expenditure	(2.07)**	(1.23)	(0.07)	(5.98)***
Population	1.061	0.999	0.975	1.096
	(14.30)***	(6.65)***	(8.02)***	(20.78)***
Democracy	0.266	0.126	0.281	-0.128
	(0.49)	(0.17)	(0.39)	(0.50)
Per Capita GDP	0.347	0.340	0.243	0.358
	(3.46)***	(1.54)	(1.23)	(5.41)***
Corruption Perception	-0.409	-0.444	-0.305	0.093
Index	(1.37)	(1.33)	(0.92)	(0.68)
Land Area	0.012	-0.043	0.005	0.046
	(0.17)	(0.33)	(0.05)	(0.90)
Time Trend			-0.058	
			(1.75)*	
Constant	-13.794	-11.558	-11.703	-16.187
	(6.73)***	(2.99)***	(3.61)***	(15.01)***
Observations	64	64	64	64
R-squared	0.87			
Number of Countries		18	18	18

Absolute value of t-statistics in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 7. Regression Results for SO_2

	Model (1) Pooled OLS With Robust SE	Model (2) RE	Model (3) RE w/Time Trend	Model (4) FGLS/Hetero
		Dependent Variable: Logarithm of SO2		
Ratio of Business Tax	0.915	-0.010	0.170	0.690
	(1.76)*	(0.02)	(0.32)	(1.55)
Ratio of Property tax	-0.108	0.022	0.002	-0.097
at Central Level	(1.36)	(0.26)	(0.03)	(1.69)*
Ratio of Property tax	0.057	0.215	-0.129	0.115
at Local Level	(0.39)	(0.80)	(0.56)	(1.16)
Ratio of Health	-0.040	-0.157	0.036	-0.073
Expenditure	(0.66)	(2.70)***	(0.60)	(1.59)
Population	1.155	1.121	1.095	1.121
	(4.88)***	(2.76)***	(3.18)***	(5.88)***
Democracy	-1.394	-0.468	-0.356	-0.939
	(1.43)	(0.67)	(0.64)	(1.04)
Per Capita GDP	-0.422	-0.383	-0.697	-0.678
	(2.05)**	(1.06)	(2.29)**	(3.63)***
Corruption Perception	1.189	-0.256	0.368	1.390
Index	(2.35)**	(0.75)	(1.24)	(2.95)***
Land Area	0.198	-0.025	-0.001	0.286
	(0.89)	(0.06)	(0.00)	(1.50)
Time Trend			-0.166	
			(5.22)***	
Constant	-16.603	-6.955	-5.620	-13.942
	(3.56)***	(1.05)	(1.02)	(3.61)***
Observations	57	57	57	57
R-squared	0.83			
Number of Countries		17	17	17

Absolute value of t-statistics in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 8. Regression Results for CO_2

	Model (1) Pooled OLS with Robust SE	Model (2) RE	Model (3) RE w/Time Trend	Model (4) FGLS/Hetero
	Dependent Variable: Logarithm of CO2			
Ratio of Business Tax	0.057	0.056	0.057	0.210
	(0.35)	(0.57)	(0.60)	(2.68)***
Ratio of Property tax	-0.112	-0.027	-0.031	-0.097
at Central Level	(4.83)***	(1.25)	(1.53)	(7.35)***
Ratio of Property tax	-0.133	-0.100	-0.118	-0.065
at Local Level	(2.32)**	(1.60)	(1.97)**	(2.03)**
Ratio of Health	0.035	-0.015	-0.002	-0.003
Expenditure	(1.60)	(1.72)*	(0.26)	(0.29)
Population	0.969	0.929	0.953	0.969
	(22.82)***	(8.58)***	(8.93)***	(44.75)***
Democracy	-0.114	0.040	0.093	0.072
	(0.57)	(0.56)	(1.31)	(0.50)
Per Capita GDP	0.177	0.344	0.370	0.226
	(1.27)	(4.02)***	(4.42)***	(3.66)***
Corruption Perception	0.843	0.095	0.039	0.849
Index	(2.61)**	(0.96)	(0.41)	(5.35)***
Land Area	0.116	0.128	0.120	0.158
	(2.87)***	(1.69)*	(1.61)	(9.65)***
Time Trend			-0.022	
			(3.03)***	
Constant	-9.229	-8.404	-8.733	-10.386
	(6.67)***	(5.58)***	(5.91)***	(18.36)***
Observations	99	99	99	99
R-squared	0.92			
Number of Countries		27	27	27

Absolute value of t-statistics in parentheses

* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 9. Summary for the Results of Model 3

	NO_x	CO	SO_2	CO_2
Ratio of Business Tax	**(+)**	+	+	+
Ratio of Property tax at Central Level	-	-	+	-
Ratio of Property tax at Local Level	**(-)**	-	-	**(-)**
Ratio of Health Expenditure	-	-	+	-
Population	**(+)**	**(+)**	**(+)**	**(+)**
Democracy	+	+	-	+
Per Capita GDP	**(+)**	+	**(-)**	**(+)**
Corruption Perception Index	-	-	+	+
Land Area	**(-)**	+	-	+
Time trend	**(-)**	**(-)**	**(-)**	**(-)**

Note: we use + to denote positive coefficients and – for negative ones. Where the results are significant, we put them in bold and also in parentheses.

Appendix A General Form Feasible Generalized Least Squares (FGLS)

and Random Effects Methods (REM)[102]

Consider the model in the general form

$$y_{i,t} = x_{i,t}\beta + v_{i,t}, \quad t = 1, 2, ..., T$$

Or, $y_{i,t} = x_{i,t}\beta + c_i + u_{i,t}, \quad t = 1, 2, ..., T$

Where c_i is the unobserved country heterogeneity and time-invariant.

As we already explained, the differentiation between fixed effects regressions and random effects regressions mainly lies in whether or not the unobserved effects c_i is correlated with the observed explanatory variables $x_{i,t}$, $t = 1, 2, ..., T$. According to the results of Hausman specification test we performed, it is necessary that we treat c_i as uncorrelated with $x_{i,t}$, and therefore we should follow random effects estimation.

The random effect estimation is the weighted average of the within (or fixed effects) regression and between regression. To illustrate, we take the model above,

$$y_{i,t} = x_{i,t}\beta + c_i + u_{i,t}, \quad t = 1, 2, ..., T \qquad (1)$$

And take the averages of the function, we then have

$$\bar{y}_i = \bar{x}_i\beta + c_i + \bar{u}_i, \quad t = 1, 2, ..., T \qquad (2)$$

Where $\bar{y}_i = \sum_t \frac{y_{i,t}}{T_i}$, $\bar{x}_i = \sum_t \frac{x_{i,t}}{T_i}$, and $\bar{u}_i = \sum_t \frac{u_{i,t}}{T_i}$

(2) – (1), we will have

$$(y_{i,t} - \bar{y}_i) = (x_{i,t} - \bar{x}_i)\beta + (u_{i,t} - \bar{u}_i), \; t = 1, 2, ..., T \qquad (3)$$

[102] In this part, we mainly follow the notation used in Wooldridge (2002), chapter 7 and chapter 10.

Applying OLS to estimate (3), we can get fixed effects estimators (or within estimators), and applying OLS to (2), we will have between estimators. The random effect regression is the weighted averages of the within and between estimator, which can take the form of

$$(y_{i,t} - \theta\overline{y}_i) = (x_{i,t} - \theta\overline{x}_i)\beta + (u_{i,t} - \theta\overline{u}_i),\ t = 1, 2, ..., T \qquad (4)$$

With θ be the weight put on the between transformation. θ takes the value of [0,1]. When $\theta = 0$, the random effects regression becomes OLS; while when $\theta = 1$, the random effects regression becomes the fixed effects regression.

In estimation process, we usually use generalized least squares (GLS) to estimate the random effect estimators. And depending on the assumptions we make, we can carry out general form GLS or the random effects model (REM) that we traditionally deal with.[103] In GLS regressions, we assume that the unobserved effects c_i is uncorrelated with the observed explanatory variables, or $\mathrm{E}(X_{it}'c_i) = 0$. However, since c_i stays the same within the panel in each time period *t*, the composite error $v_{i,t}$ will be correlated across time. In addition, the fact that $v_{i,t}$ depends on c_i for all time periods makes this correlation not fade along the increase of the time span.

In addition, in REM we assume that the idiosyncratic error is serially uncorrelated and homoskedastic, or $\mathrm{E}(u_{it}^2) = \sigma_u^2$ and $\mathrm{E}(u_{it}u_{is}) = 0$ for all $t \neq s$, $t = 1,2,...,T$. Therefore, the serial correlation comes only from c_i. And if we denote $\mathrm{E}(c_i^2) = \sigma_c^2$, we

[103] This follows the language in Wooldridge (2002). Here the general form GLS is so called simply because it is more generalized than the REM. Special assumptions still have to be made for the idiosyncratic error terms in order to perform the regressions, however.

will have that $\mathrm{E}(v_{it}^2) = \mathrm{E}(c_i^2) + \mathrm{E}(u_{it}^2) = \sigma_c^2 + \sigma_u^2$, and

$\mathrm{E}(v_{it} v_{is}) = \mathrm{E}[(c_i + u_{it})(c_i + u_{is})] = \sigma_c^2$.

Therefore, under REM, the variance matrix will take the following form

$$\Omega = \mathrm{E}(v_i v_i') = \begin{pmatrix} \sigma_c^2 + \sigma_u^2 & \sigma_c^2 & \cdots & \sigma_c^2 \\ \sigma_c^2 & \sigma_c^2 + \sigma_u^2 & \cdots & \vdots \\ \vdots & \vdots & \ddots & \sigma_c^2 \\ \sigma_c^2 & \cdots & \sigma_c^2 & \sigma_c^2 + \sigma_u^2 \end{pmatrix}$$

If we have I_T as the identity matrix, and $J_T J_T'$ as the $T \times T$ matrix with unity in every element, we can write the above matrix in the form

$$\Omega = \sigma_u^2 I_T + \sigma_c^2 J_T J_T'$$

Then under this assumption, we only need to estimate two unknowns for each T, σ_c^2 and σ_u^2. There are different methods of estimating σ_c^2 and σ_u^2, as discussed in Wooldridge (2002) and Hsiao (2003). Then, using this variance matrix, we can obtain the FGLS estimator by the following formula

$$\hat{\beta}_{RE} = \left(\sum_{i=1}^{N} X_i' \hat{\Omega}^{-1} X_i \right)^{-1} \left(\sum_{i=1}^{N} X_i' \hat{\Omega}^{-1} y_i \right)$$

This is what we did in our regression model 2 and 3. As we mentioned before, the difference between 2 and 3 is that we include year dummies in model 3, in order to take into account the time effects. Even though we generally do not have many time periods available, it is more appropriate to take the time effect into consideration. We do not report the dummies in the result tables, however. Due to the nature of the panel data set

we have, even though unbalanced, we deem these two models are more appropriate for our analysis, especially model 3.[104]

However, if we do not assume the composite errors v_{it} are composed of country heterogeneity c_i and idiosyncratic errors u_{it}, with the latter well-behaved as in REM, we will need to use the general FGLS. We will use the form

$$\hat{\beta}_{FGLS} = \left(\sum_{i=1}^{N} X_i' \hat{\Omega}^{-1} X_i \right)^{-1} \left(\sum_{i=1}^{N} X_i' \hat{\Omega}^{-1} y_i \right)$$

Where $\hat{\Omega} = N^{-1} \sum_{i=1}^{N} \hat{\hat{v}}_i \hat{\hat{v}}_i'$, and $\hat{\hat{v}}_i = y_i - X_i \hat{\hat{\beta}}$ is the pooled OLS residuals.

At one extreme case, if we assume v_{it} is i.i.d, we will have that $\hat{\beta}_{FGLS}$ is the same as pooled OLS, $\hat{\beta}_{SOLS}$. As the other extreme, for the most generalized form, we basically need to estimate each element of the variance matrix; with a total of $T(T+1)/2$ if we do not make any specific assumptions. But in general, there is a robust variance matrix available and takes the form

$$A\text{var}(\hat{\beta}) = (\sum_{i=1}^{N} X_i' \hat{\Omega}^{-1} X_i)^{-1} (\sum_{i=1}^{N} X_i' \hat{\Omega}^{-1} \hat{v}_i \hat{v}_i' \hat{\Omega}^{-1} X_i) (\sum_{i=1}^{N} X_i' \hat{\Omega}^{-1} X_i)^{-1}$$

However, usually for the general GLS, we assume that the composite error v_{it} take some special form, which will ease our regression a lot. For example if we assume that the composite errors are heteroskedastic, we can correct for the heteroskedasticity by specifying the relevant variance structures. This is what we did in our model 4. Since we

[104] And the Breusch and Pagan Lagrangian multiplier test for random effects gives us significant results for random regressions with all four pollutants, which confirms the existence of country heterogeneity (Breusch and Pagan 1980).

have a cross section time series dataset, we assume that the variance for each panel differ, which results in heteroskedasticicy.

More specifically, in model 4, we assume that $\mathrm{E}(u_{it}^2) = \sigma_{u_i}^2$, or there is a unique $\sigma_{u_i}^2$ for each panel and different across panels, therefore we need to estimate the unique $\sigma_{u_i}^2$ for each group. We also assume for simplicity that $\mathrm{E}(v_{it}v_{is}) = 0$. The variance matrix will then take the following form

$$\Omega = \mathrm{E}(v_i v_i') = \begin{pmatrix} \sigma_{u_1}^2 & 0 & \cdots & 0 \\ 0 & \sigma_{u_2}^2 & \cdots & \vdots \\ \vdots & \vdots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_{u_n}^2 \end{pmatrix}$$

Or, to write in a matrix form, it will be $\Omega = \sigma_{u_i}^2 I_T$.

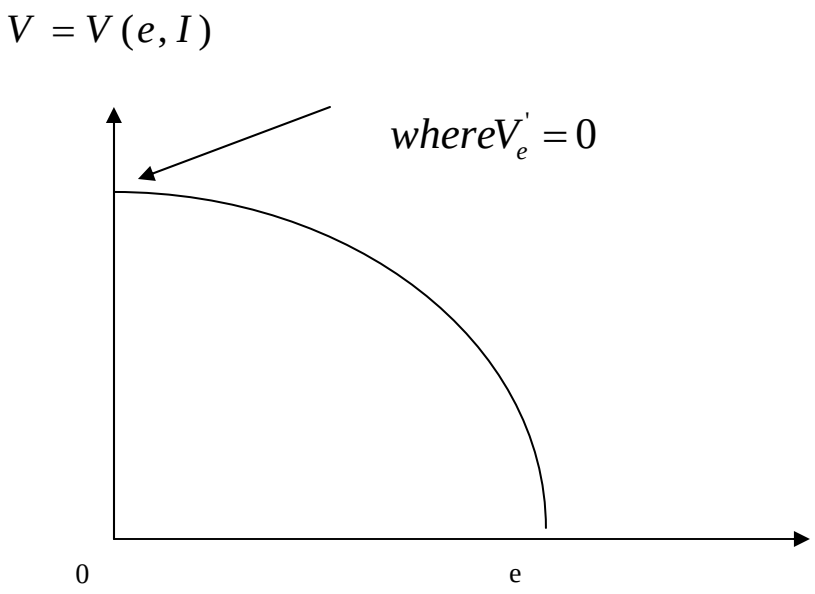
Thus in model 4, in addition to σ_c^2, it is necessary to estimate the $\sigma_{u_i}^2$ for each T.

In this case, the variance matrix will take the form $\Omega = E(u_i u_i') + \sigma_c^2 j_T j_T'$. After pooled OLS estimations, these covariance estimates and autocorrelation parameters are not difficult to obtain. And the FGLS estimation with the specially structured Ω can be obtained relatively easier.

Appendix B Proof of propositions

C-1. Proof of Proposition II.

In this case, the F.O.C is $\tau_v V_e^{'}(e,I)=0$ the only chance for $V_e^{'}=0$ is $e=0$. The government has no incentive and thus provides zero effort in pollution control, which means that the pollution level will be very high.

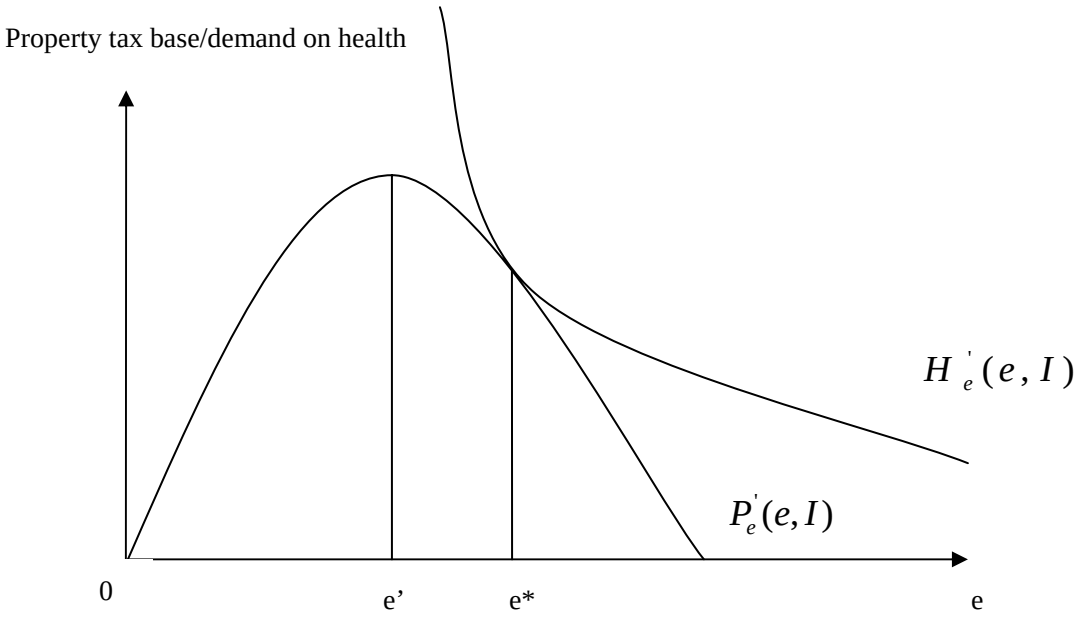


C-2. Proof of Proposition III.

In this case, the F.O.C is

$\beta \cdot \tau_p \cdot P_e^{'}(e,I) - \gamma \cdot R \cdot H_e^{'}(e,I) = 0$.

To make this equation hold, since we have P is concave in e, or $P_e^{'}(e,I) > 0$ before some point e' and $P_e^{'}(e,I) < 0$ after that; while H is convex in e, or $H_e^{'}(e,I) < 0$, the only possible solution has to be on the part that $P_e^{'}(e,I) < 0$.



If pollution level is high, which shows that the government effort e is low, then increase in e would increase the value of property and save on the expenditure on health care at the same time, as illustrated in the diagram above, for the part before *e'* . Therefore, the government has great incentive to increase *e* and control pollution. However, the government can not increase *e* too much. If the government effort *e* becomes so high that it not only lowers the pollution level and reduces the expenditure on health, but also at the same time drives down the property value, as illustrated in the diagram for point beyond *e'*, the government will have to balance the gain from saving on health expenditure and loss from drop in property tax. We would expect the equilibrium to be achieved at point *e**, while *H* and *P* are cotangent to each other. At *e** we have that the gain from savings on expenditure on healthcare is equal to the loss of property tax resulting from the lower property values.

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